PRACTICAL CHEMISTRY

NEWELL

REVISED EDITION

EXPERIMENTS IN PRACTICAL CHEMISTRY

TO ACCOMPANY

NEWELL'S PRACTICAL CHEMISTRY

BY

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PREFACE

This book is the experimental part of the author's textbook entitled Practical Chemistry.

These experiments are essential for teaching the fundamental facts and principles of chemistry. Many practical experiments are included.

The experiments vary in length, difficulty, and application. There are more experiments than a class can do in a year of chemistry. Teachers should select experiments which provide a course adapted to their requirements. Ample material is available for different courses — practical, fundamental with practical applications, college preparatory, short, and long.

The directions for performing the early experiments are rather full. In the quantitative experiments, besides detailed directions, the object is stated and the calculation is indicated or illustrated.

The apparatus for the pupil's experiments is simple. Many parts are interchangeable, and several types of apparatus are shown. The quantities of chemicals have been carefully chosen, and, as a rule, the chemicals are the less expensive ones. The Appendix contains lists of apparatus and chemicals.

The Demonstration Experiments are intended for use in the classroom. The apparatus for these experiments is in List C in the Appendix.

The Introduction contains general laboratory directions. The directions for weighing (§ **8**) are given in detail.

The author is indebted to many teachers for advice, especially to his associates in the chemistry department of Boston University. He is under special obligation to Mr. Harold C. Spencer, Boston University, 1914, for making the drawings.

L. C. N.

January, 1923

PREFACE TO REVISED EDITION

Several experiments have been revised and minor corrections made in this edition.

L. C. N.

April, 1929

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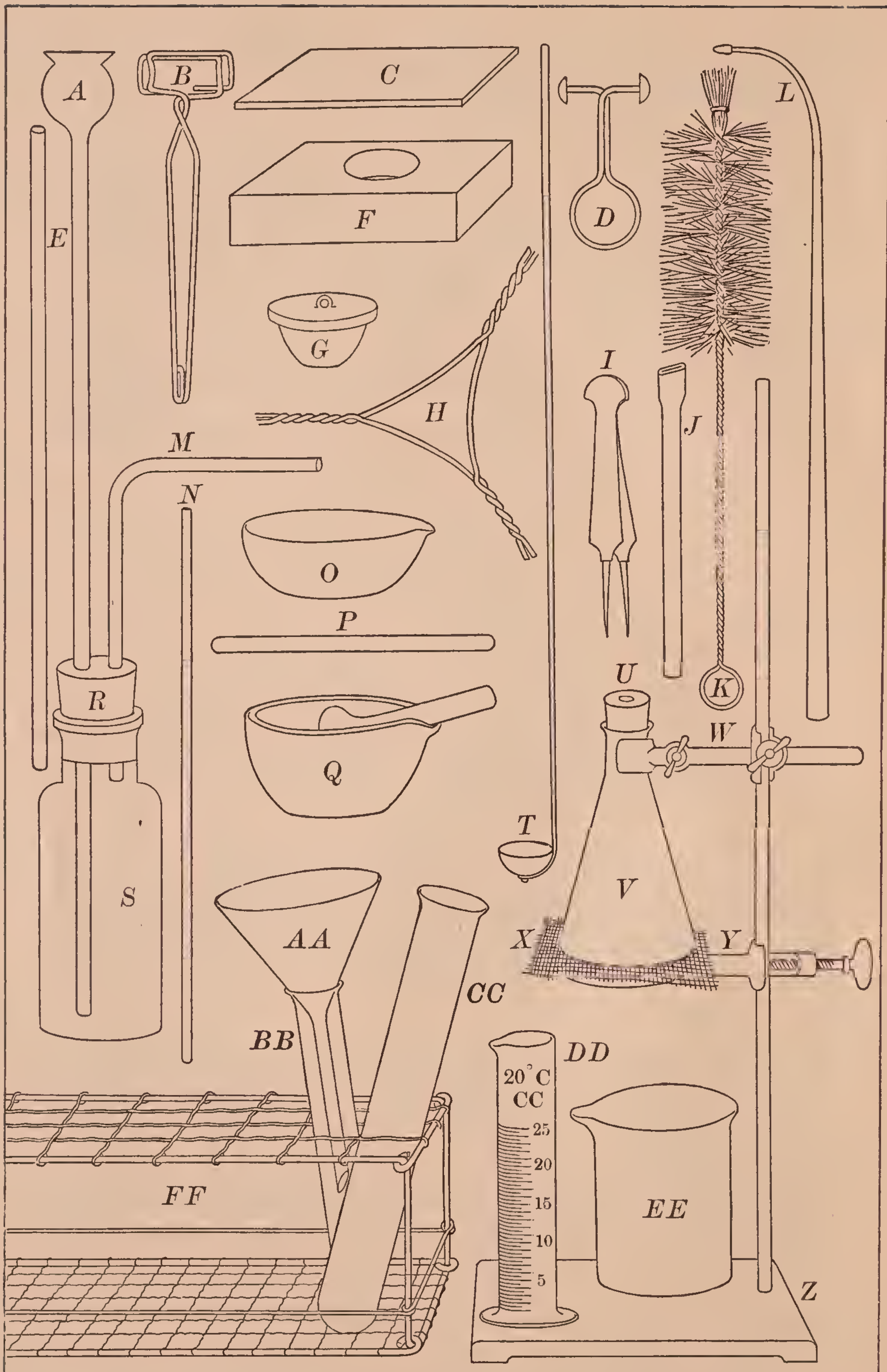
CONTENTS

Numbers indicate experiments. College preparatory experiments are marked (C) — (C*) recommended, demonstration experiments (D), and quantitative experiments (Q).



Frontispiece

FIG. I. — Apparatus frequently used in the laboratory

EXPERIMENTS IN PRACTICAL CHEMISTRY

INTRODUCTION

1. General directions for the pupil. — The apparatus you will use frequently is shown on the opposite page. The pieces are lettered as follows: —

A — Thistle tube. *B* — Test tube holder. *C* — Glass plate. *D* — Pinch clamp. *E* — Glass tube. *F* — Crucible block. *G* — Porcelain crucible (covered). *H* — Triangle. *I* — Forceps. *J* — Blowpipe tube. *K* — Test tube brush. *L* — Blowpipe. *M* — Right-angle bend. *N* — Glass rod. *O* — Porcelain evaporating dish. *P* — Glass plug. *Q* — Mortar and pestle. *R* — Rubber stopper (2-hole). *S* — Bottle. *T* — Deflagrating spoon. *U* — Rubber stopper (1-hole). *V* — Erlenmeyer flask. *W* — Iron clamp. *X* — Wire gauze. *Y* — Iron ring. *Z* — Iron stand. *AA* — Funnel. *BB* — Test tube (small). *CC* — Test tube (large). *DD* — Graduated cylinder. *EE* — Beaker. *FF* — Test tube rack (shown in part).

Use Fig. I in preparing a list of the apparatus in your desk. When your set of apparatus agrees with the list, hand the completed list to the Teacher.

Some general apparatus will be found in the laboratory and special apparatus will be supplied as needed. Use this apparatus as directed.

Besides the apparatus in your desk, you will need a rubber apron and a pair of sleeves, or something similar, to protect your clothes.

You will need a laboratory notebook. Write your name and the number of your desk on the notebook. In this book you should keep a neat and accurate account of all the experiments you perform. The Teacher will give special directions for writing the notes, handing in the book, and correcting errors. In general, your record of each experiment should include: —

(1) The number and title of the experiment and the date.

(2) An account of the experiment — brief, but full enough to permit a correct repetition of the experiment or its essential parts.

(3) Answers to all questions — not merely yes or no, but an answer involving the question.

(4) The numbers and letters which correspond to those in the directions, *e.g.* 1, I, (1), **a**, etc.

(5) All numerical data, *e.g.* weights and volumes, in the form given in the directions.

(6) A simple sketch of the apparatus (if time permits).

(7) A table of contents.

To do experiments successfully, you must meet certain requirements. **Before the laboratory period** find out what experiment is to be done, read the directions carefully, and plan the work as well as you can. **When you enter the laboratory**, open your desk at once, or have it opened, take out the necessary apparatus, and begin to work without delay. **When you are doing an experiment in the laboratory**, follow the directions carefully, especially about quantities of chemicals, heating, and weighing; work and think independently. If you need assistance, ask the Teacher, not your neighbor. Your work will be more profitable if you follow these suggestions: —

(*a*) Learn as soon as possible the name of each piece of apparatus, and how to use it.

(*b*) Learn how to perform skillfully the operations so frequently done in the laboratory, *e.g.* heating, filtering, weighing (see §§ **2**, **4**, **8** below).

(*c*) Learn how to set up apparatus, inspect it, and correct defects.

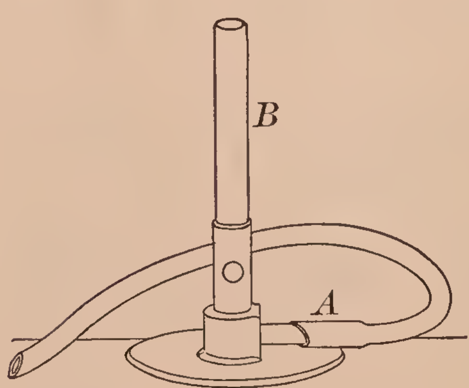


Fig. II. — Bunsen burner

(*d*) Learn how to do arithmetical work quickly and accurately, and to check results.

Before you leave the laboratory, be sure your apparatus is clean and put away, the water and the gas are turned off, and your desk is in just as good order as you would like to find it.

2. How to use the Bunsen burner. — The Bunsen burner (Fig. II) is used as a source of heat. It is attached to a rubber tube (*A*), which is connected with the gas supply. To light the burner, turn on the gas and hold a lighted match a short distance above the top of the burner tube (*B*). The flame should be a faint blue. If it is yellow, turn the ring at the bottom of the burner until the flame is blue.

A suitable height for most experiments is about 10 cm. (or 4 in.). Adjust the gas pressure until the flame is about this height. The hottest part of the flame is near the top.

In heating with the Bunsen burner follow these directions: —

a. Light the burner before a piece of apparatus is held over it or before it is placed beneath a wire gauze which supports a dish or a flask.

b. Test tubes — used frequently — should be dry on the outside. If the test tube contains a solid, heat gradually by moving the tube in and out of the flame. If the test tube contains a liquid, only the part containing the liquid should be put in (or above) the flame. When the liquid begins to boil, the test tube should be removed from the flame for an instant or held over it. As a rule a test tube holder should be used (Fig. 3).

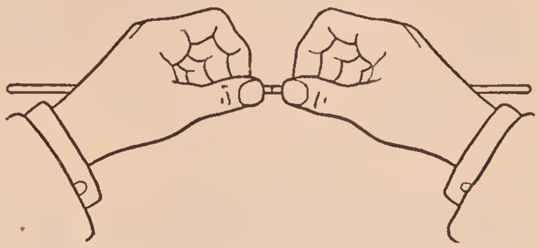


FIG. III. — Cutting a glass tube

c. Do not heat *empty* glass apparatus, *e.g.* beakers. In heating a beaker containing a liquid, do not use the free flame, but place the vessel on a wire gauze which stands on an iron ring. Porcelain dishes should also be placed on a gauze. Porcelain crucibles may be heated with a free flame. All porcelain apparatus should be heated and cooled gradually.

3. Cutting, bending, and drawing glass tubing. — a. Cutting. — Determine the length needed, lay the tube on the desk, and with forward strokes of a triangular file make a short, deep scratch where the tube is to be cut. Grasp the tube in both hands, and hold the thumbs together *opposite* the scratch; now push gently with the thumbs, pull at the same time with the hands, and the tube will break at the desired point (Fig. III). The sharp ends should be smoothed by rotating them slowly in the Bunsen flame until a yellow color is distinctly seen or until the end becomes red hot; this operation is called fire polishing (Fig. IV).

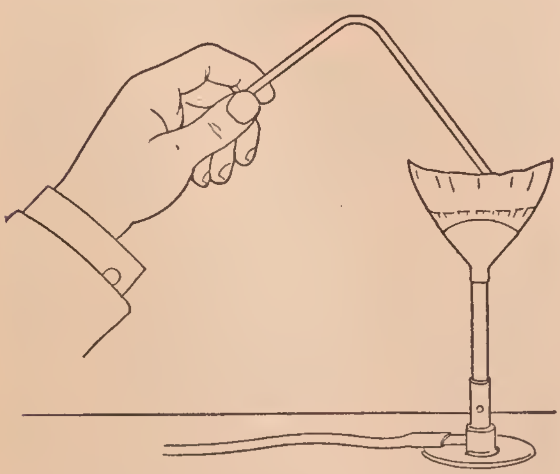


FIG. IV. — Fire polishing a glass tube

b. **Bending.** — Glass tubes can be bent in an ordinary illuminating gas flame, but the Bunsen flame is usually flattened by a wing-top (Fig. V). Attach the wing-top to the top of the burner tube before lighting the gas. The flattened Bunsen flame should be slightly yellow and about 7 centimeters (2.5 inches) wide for ordinary bends. A **right-angle bend** is easily made. Determine the part where the tube is to be bent. Grasp the tube in both hands, and hold it so that this part is directly over the flame (Fig. VI). Slowly rotate it between the thumbs and forefingers, and gradually lower it into the flame. Continue to rotate it until the glass feels soft and ready to bend. Then remove it from the flame, and slowly bend it into a right angle (Fig. VII). Use a block of wood to assist the eye in making an exact right angle. The bent part of the tube can be annealed (to prevent cracking) by rotating it in a yellow flame until it becomes coated with soot, and then allowing it to cool slowly. Tubes can be bent into an **oblique angle** by heating them through about twice the space required for a right angle (Figs. VIII, IX); a very slight bend can be made by holding the

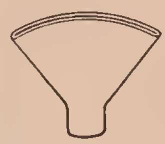


FIG. V. — A wing-top burner

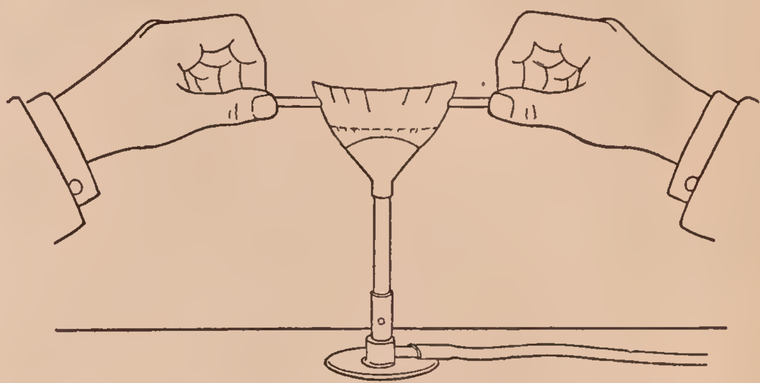


FIG. VI. — Bending a tube into a right angle — first step

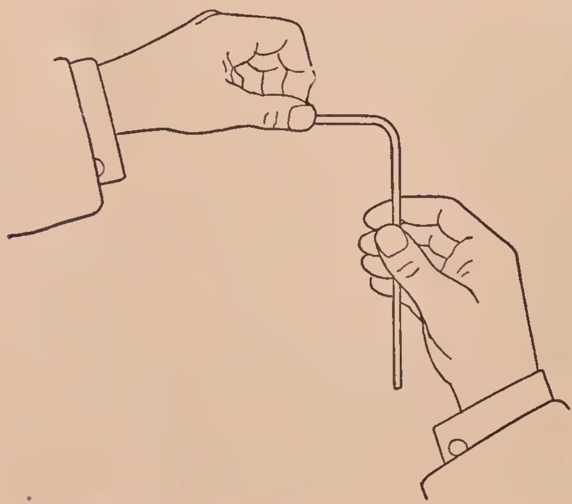


FIG. VII. — Bending a tube into a right angle — second step

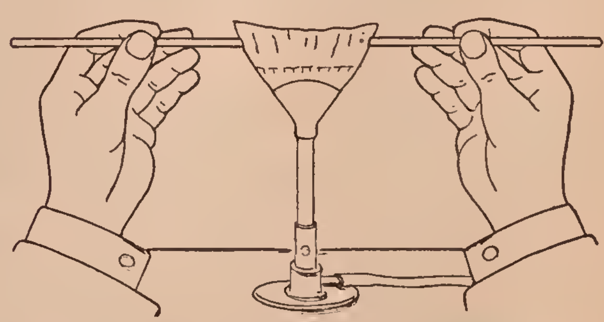


FIG. VIII. — Bending a tube into an oblique angle — first step

tube across the flame, heating a short space, and then bending slightly.

c. **Drawing.** — Glass tubes can be drawn into two pointed tubes thus: Heat the tube as in **b** through about 2.5 centimeters (1 inch) of its length, remove it from the flame and slowly pull it apart a short distance; let it cool for a few seconds, and then pull it quickly to the desired length. **Stirring rods** can be made from glass rod in the same way.

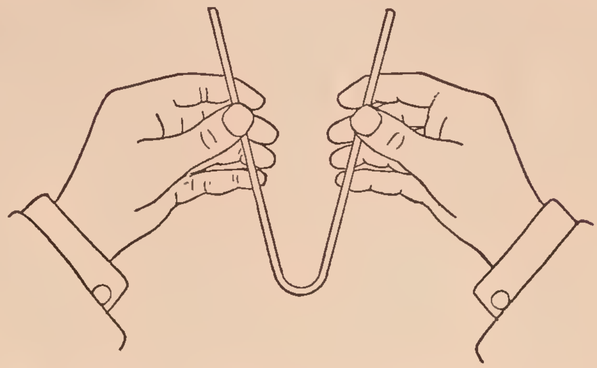


FIG. IX. — Bending a tube into an oblique angle — second step

4. **Filtering.** — A solid may be separated from a liquid by filtering. A circular piece of filter paper is folded to fit a glass funnel, and when the mixture is poured upon this paper the solid — called the residue or precipitate — is retained, while the liquid — called the filtrate — passes through and may be caught in a test tube or any other vessel.

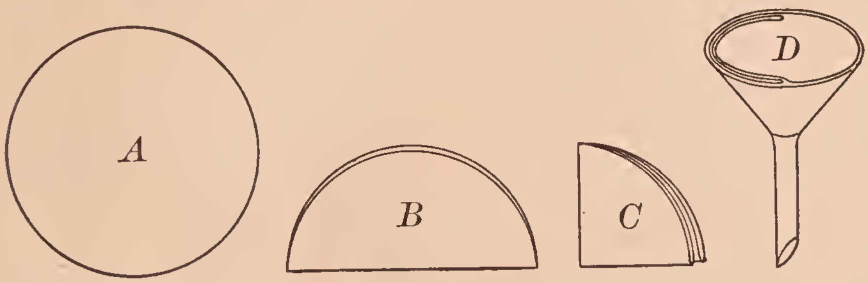


FIG. X. — Preparing a filter paper

The filter paper is prepared for the funnel by folding the circular piece *A* (Fig. X) into the shapes *B* and *C*. The folded paper is then opened so that three thicknesses are on one side and one on the other. **To filter,** the cone-shaped paper (from *C*) is placed in the funnel (*D*) and moistened with water, so it will stick to the funnel. The liquid to be filtered may be poured directly from the vessel upon the paper or down a glass rod which touches the edge of the

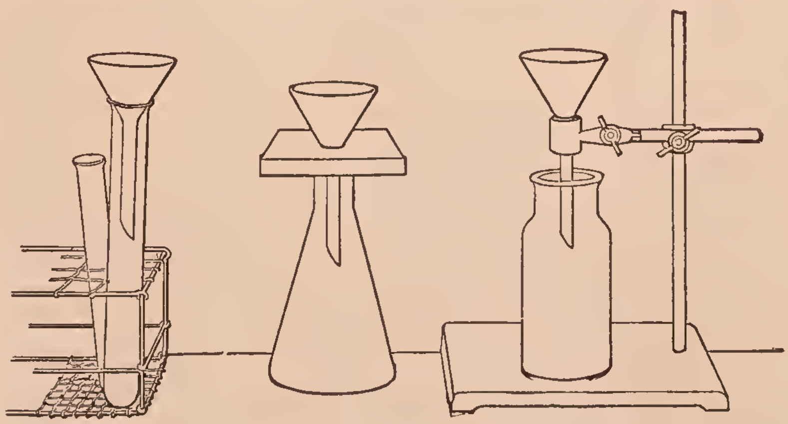


FIG. XI. — Funnel supported for filtering

vessel (**6 a**); the lower end of the rod should nearly touch the paper inside the funnel. The funnel can be supported as shown in Fig. XI.

5. Constructing and arranging apparatus. — The various parts of the apparatus should be assembled and put together as completely as possible before starting the experiment. The parts that are to fit each other should be connected so that all joints are gas-tight. In long experiments or those involving weighing the apparatus should be inspected by the Teacher.

a. To insert a glass tube into a rubber tube. — Cut one end of the rubber tube at an angle, moisten the smoothed end of the glass tube with water, place the end of the glass tube in the angular-shaped cavity so that both tubes are at about a right angle, grasp the end of the rubber tube firmly and slip it slowly up and over the end of the glass tube.

b. To push a glass tube through a hole in a stopper. — Wet one end of the tube with water and grasp it firmly near this end; hold the stopper between the thumb and forefinger of the other hand, and work the tube through the hole by a gradual rotary motion. *Never* point the tube toward the palm of the hand that holds the stopper. *Never* grasp a bent tube at the bend when inserting it into a stopper — it may break and cut the hand severely.

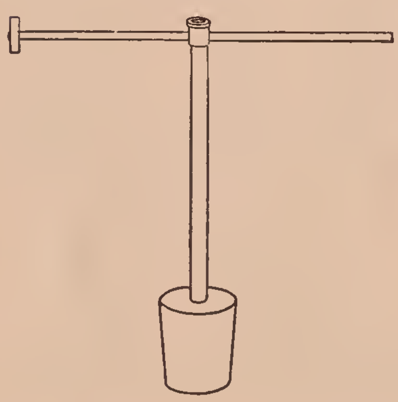


FIG. XII. — Cork borer in a cork

c. To bore a hole in a cork. — Select a cork free from cracks or channels and use a borer which is one size smaller than the desired hole. Hold the cork between the thumb and forefinger, press the larger end against a firm board, and slowly push the borer (previously moistened with water or soap solution) by a rotary movement through the cork, taking care to bore perpendicularly to the cork (Fig. XII). If the hole is too small, enlarge it with a round file. Push the small cylinder of cork finally out of the borer with the handle.

d. To make a test wire. — (1) **Platinum.** Rotate one end of a piece of glass rod, about 10 centimeters (4 inches) long, in the flame until it softens. At the same time grasp a piece of platinum wire about 7 centimeters (3 inches) long firmly in the forceps about 1

centimeter (0.5 inch) from the end, and hold it in the flame. When the rod is soft enough, gently push the hot wire into the rod.

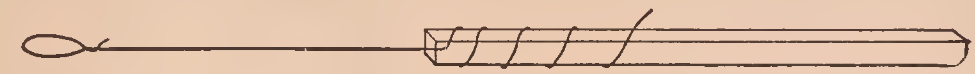


FIG. XIII. — Test wires — platinum (upper), nichrome (lower)

(2) **Nichrome.** Wind a piece of nichrome wire around a match stick. The completed wires are shown in Fig. XIII.

6. Pouring liquids and transferring solids. — a. Liquids can be poured from a test tube or dish without spilling by moistening a glass rod with the liquid, holding the rod against the edge of the vessel, and then pouring the liquid slowly down the rod (Fig. XIV).

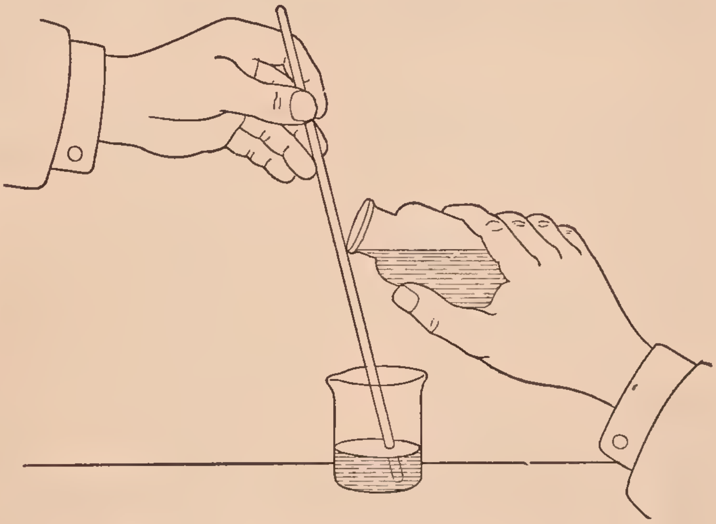


FIG. XIV. — Pouring a liquid down a rod

b. Liquids should be poured from a bottle by holding the bottle as shown in Fig. XV. Note that the stopper and bottle are held in the same hand. The stopper is first removed by hold-

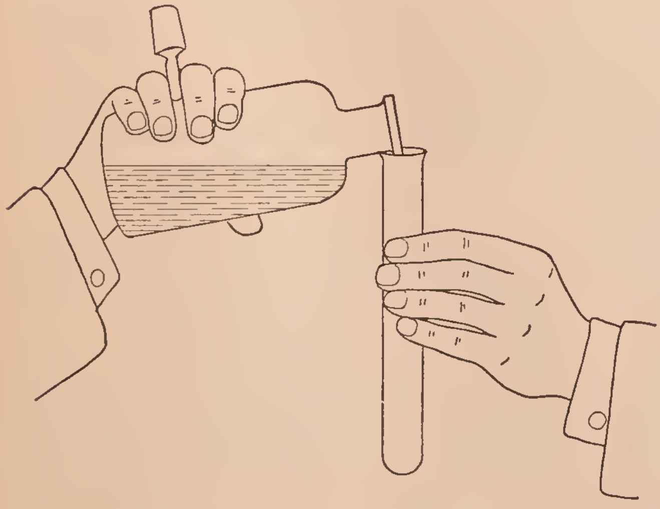


FIG. XV. — Pouring a liquid from a bottle

FIG. XVI. — Removing the stopper from a bottle

ing the palm of the hand upward and grasping the stopper between the fingers before the bottle is lifted (Fig. XVI). All stoppers

should be removed this way when possible, and not laid down on the desk. The drop on the lip of the bottle should be touched with the stopper before the latter is put into the bottle.

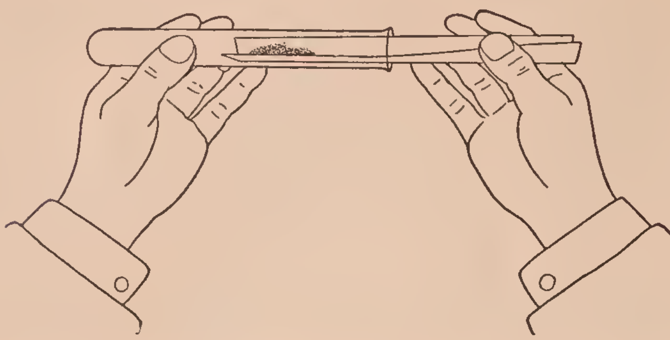


Fig. XVII. — Putting a solid into a tube — first step

c. Solids should never be poured directly from a large bottle into a test tube or dish. Use a spoon, spatula, or piece of smooth paper; or rotate the bottle slowly so that the solid will roll out in small quantities. If the solid is dirty (*e.g.* charcoal), catch the solid on a narrow strip of paper creased lengthwise, and introduce the solid from the paper into the test tube as shown in Figs. XVII, XVIII.

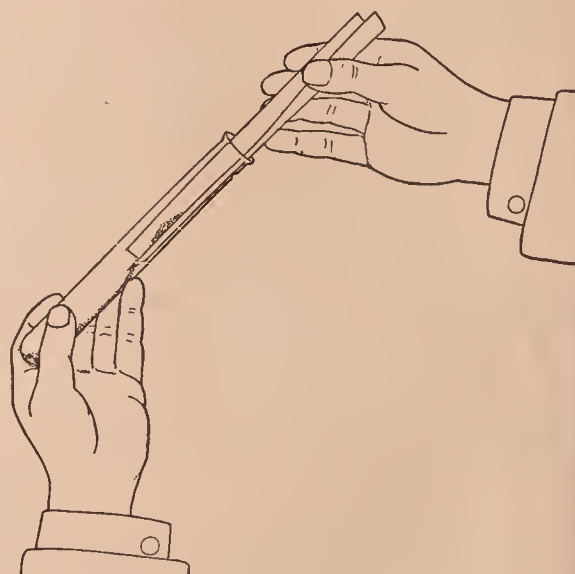


Fig. XVIII. — Putting a solid into a tube — second step

7. Collecting gases. — Gases are usually collected over water in a pneumatic trough; one form is shown in outline in Fig. XIX (right). The bottle (or tube) to be filled with gas is first filled with water, covered with a piece of filter paper, inverted (Fig. XIX — left), and placed mouth downward on the support of the trough, which is previously filled with water just above the support (Fig. XIX). The paper is then removed. Glass plates instead of filter paper may be used to cover the bottle. The gas escapes from the delivery tube, bubbles up through the water into the vessel, and forces the water out of the vessel. Gases not very soluble in water (*e.g.* oxygen and hydrogen) are collected in this way.

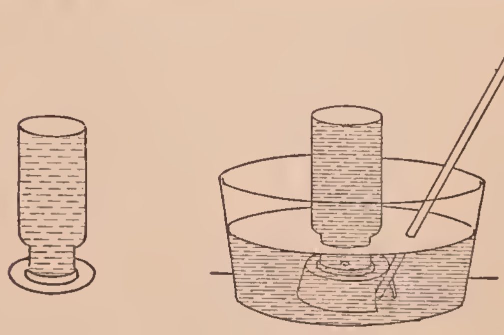


Fig. XIX. — Pneumatic trough in outline (right), inverted bottle of water (left)

Some heavy gases, *e.g.* hydrochloric acid, chlorine, and sulphur dioxide, are collected by allowing the gas to flow downward into an empty bottle, *i.e.* by downward displacement (Fig. 41). Ammonia and other light gases are collected by allowing the gas to flow upward into a bottle, *i.e.* by upward displacement (Fig. 48).

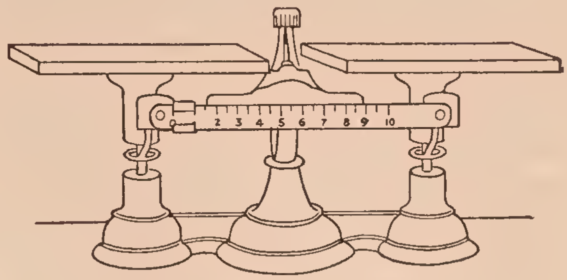


FIG. XX. — Scales

8. Weighing. — Weighing may be approximate or accurate. **Approximate weighings** are made on the **scales** (Fig. XX) and **accurate weighings** on the horn pan balance (Fig. XXI) or on the chemical balance (Fig. XXII). The METRIC SYSTEM of WEIGHTS is used and should be studied before weighing is attempted. (See APPENDIX, § 1.) Note these general directions: —

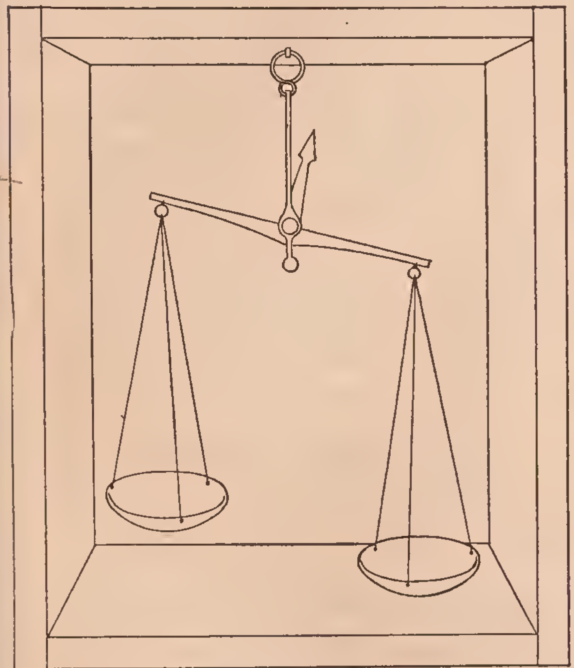


FIG. XXI. — Horn pan balance hanging in a box (open in front and closed in back) to protect the balance from air currents

(1) Before weighing, see that the scales and balances are clean and properly adjusted. If out of order, do not adjust them yourself, but report to the Teacher.

(2) Put objects on the left side and weights on the right. Heavy objects and weights should be put near the center of the pan.

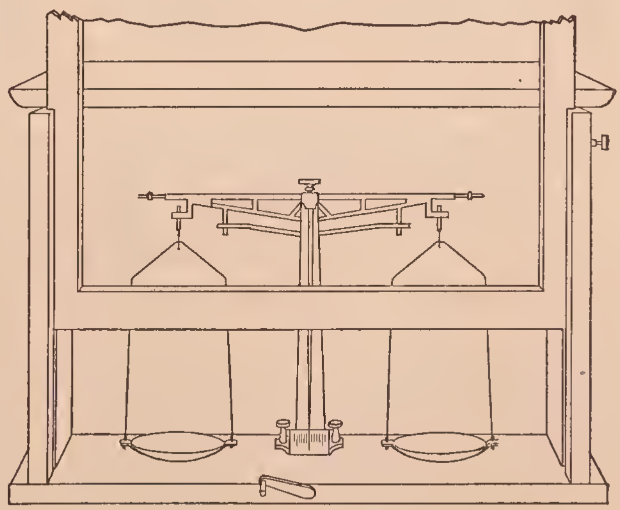


FIG. XXII. — Chemical balance in a glass case (front partly raised)

(3) Substances should not be placed directly on the platform or pan, except pieces of certain metals, *e.g.* zinc or aluminium, or porcelain and glass objects.

In **weighing on the scales**, put a piece of paper of about equal size on each platform; the paper on the left should be creased. Take the substance from the bottle with a clean spoon or spatula, or pour it out by rotating the bottle as described in **6 c** above; if too much is taken out, do not put it back into the bottle, but throw it into the waste jar or a special bottle. Approximate weighings are made on the scales, *e.g.* the quantities of chemicals usually needed in ordinary experiments. Objects and quantities weighing over 100 gm. should be weighed on the scales.

In **weighing on the horn pan or the chemical balance**, if the substance itself should not be placed directly on the pan, weigh a small watch crystal or crucible and then weigh the substance in this vessel. Sometimes a piece of apparatus is hung from the balance hook. Accurate weighings are made on the balance, *e.g.* the exact quantities needed in quantitative experiments. Record the total weight at once in the proper place in the RECORD in the laboratory notebook — not on a scrap of paper. Enter the weight as grams and a decimal fraction, *e.g.* 5.29 grams, not 5 grams, 2 decigrams, and 9 centigrams. Record all weighings — temporary and final — in the notebook.

The **process of weighing** is as follows: —

A. Scales. — Put the object, or the paper containing the proper substance, on the left side; on the right side put one or more weights which are judged to be the approximate weight. Now add or remove (substance or) weights until the pointer swings the same number of spaces each side of the middle division. Weighings of small quantities, *e.g.* 5 grams or less, are usually made by sliding a rider along a graduated beam on the front of the scales.

B. Chemical balance. — Release the beam by turning the screw or lever. The pointer should swing the same (or very nearly the same) number of spaces each side of the central line. If it does not, consult the Teacher. If it does, proceed with the weighing. Put the object (*e.g.* crucible, dish, tube, or special substance) on the left pan and the weight judged to be equal on the right pan. Release the beam carefully by turning the screw or lever, and note the movement of the pointer. If the added weight is correct, the pointer will swing the same (or very nearly the same) number of spaces each side of the central line on the scale. If incorrect (as it usually is), slowly turn back the screw or lever and bring the balance to rest. Add or

remove the weight which is next heavier or lighter — as needed — and release again. If not correct, bring the balance to rest, and change the weights accordingly, taking care to add or remove the weights in order (*i.e.* next heavier or lighter). Continue to change the weights, bringing the balance to rest each time, until the correct weight is obtained, *i.e.* when the pointer swings the same number of spaces each side of the central line as it did at the beginning. As soon as the substance or object is weighed, note the weights on the pan and record their sum at once in the notebook, then compare the weights with those missing from the box; if correct, so indicate in the notebook, and finally check the total weight by adding the weights as they are returned to the box.

The following rules should be rigidly observed: —

a. Always bring the balance to rest before changing the weights, the object, or the substance.

b. If on releasing, the beam does not swing, arrest and release again, or fan one pan very gently.

c. Handle all weights with the forceps — not the fingers.

C. **Horn pan balance.** — The horn pan balance must be counterpoised before each weighing. This is readily done. Clean the pans with soft paper or cheesecloth. Allow them to swing freely and note which side is lighter by estimating the distances to right and left. Add bits of wire or compact wads of paper to the proper pan until the balance is counterpoised, *i.e.* until the pointer swings equal distances to the right and left. Proceed with the weighing as in **B** (noting that there is no releasing screw).

9. **Measuring.** — Liquids are measured accurately in graduated cylinders and burettes (Figs. I, *DD*, 46). The lowest point of the curved surface of the liquid, called the meniscus, is its correct height (Fig. 47).

Time can be saved by *learning and remembering* that the average ordinary test tube (15 × 1.8 centimeters or 6 × $\frac{3}{4}$ inch) holds about 30 cc. (cubic centimeters), while the large test tube (20 × 2.8 centimeters or 8 × 1 inch) holds about 75 cc. (cubic centimeters).

10. **Smelling and tasting.** — Unfamiliar substances should never be smelled or tasted except according to directions, and even then with the utmost caution. Never inhale a gas vigorously, but waft it gently with the hand toward the nose. Never ask another pupil to

inhale a gas. Taste acids, bases, and salts by touching a minute portion of the *dilute* solution to the tip of the tongue, and as soon as the sensation is detected, reject the solution at once — never swallow it.

11. Accidents. — **Cuts** should be washed in clean cold water and then covered with collodion or court plaster if slight, or bandaged if severe.

Burns should be covered with a paste made by mixing sodium bicarbonate (baking soda) and carron oil (an emulsion of lime water and oil) and then bandaged.

Acids and alkalies if spilled on the hands or spattered on the face should be washed off at once with water; if a burn is produced, this may be treated as described above.

Fires may be extinguished by sand or by carbon tetrachloride. If the clothing catches fire, a damp towel or asbestos blanket should be used.

An **emergency box** or cabinet containing "first aid" articles should be kept in a convenient place. For contents, see APPENDIX, § 6, LIST F.

EXPERIMENTS

CHEMICAL CHANGE — COMPOUNDS — ELEMENTS

(Practical Chemistry, pp. 1–10, §§ 1–14)

Experiment 1 — Chemical Change

MATERIALS. — Candle, limewater.
APPARATUS. — Block of wood, bottle.

Light a candle and stick it to a block of wood with a drop of melted candle wax.

a. Hold a cold, dry bottle over the lighted candle (Fig. 1). Remove the bottle in a moment and examine the inside. Describe what you see. What is the substance?

b. Pour some clear limewater into the bottle, and shake. Describe the change. What gas caused the change?

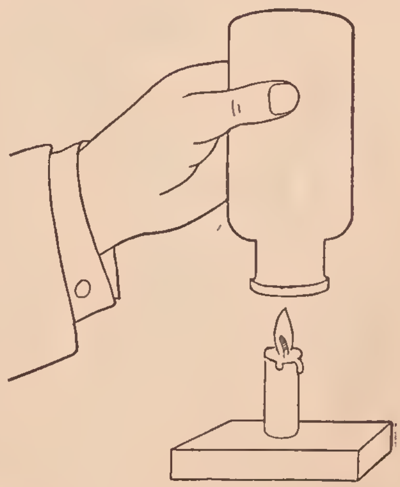


FIG. 1. — Studying a chemical change

Answer: 1. What are the two products of a burning candle?

2. Does the candle really "burn away"?

3. What does this experiment illustrate?

Experiment 2 — Properties and Chemical Change

MATERIALS. — Sulphur, copper wire, concentrated nitric acid, magnesium ribbon.
APPARATUS. — Test tubes, block of wood, forceps, Bunsen burner.

a. Examine a piece of sulphur. Note and record its properties, *e.g.* color, odor, physical state. Put a small piece on a block of wood and light the sulphur by directing the flame upon it. Observe the color and size of the flame of the burning sulphur. Note (very cautiously) the odor of the gas by brushing a little gently toward the nose.

Compare the properties (*e.g.* color, odor) of the gas with those of the sulphur.

What characteristic of chemical change does this experiment illustrate?

Do not let the sulphur burn longer than necessary. Extinguish it with a little sand, or by pressing it with a piece of stiff paper.

b. Examine a piece of clean copper wire. Note and record its properties, especially color, appearance (*e.g.* luster), and flexibility. Grasp one end of the wire with the forceps, and hold the other end in the hottest part of the Bunsen flame until the copper melts and undergoes a definite change (Fig. 2). Remove, and examine the product. Compare it with unheated copper. Is the product a different substance from the copper? Why?

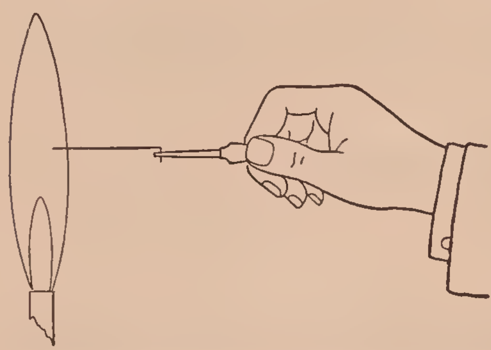


Fig. 2. — Heating copper wire in a Bunsen flame

c. Roll a piece of copper wire into a ball, drop it into a test tube one fourth full of concentrated nitric acid, and warm gently. What is the evidence of chemical change?

d. Examine a piece of magnesium ribbon. Note and record its properties, as in **a**. Grasp one end firmly with the forceps, hold the other end in the flame for an instant, and then remove it. Observe the result. Examine the product. How does it differ from magnesium?

Answer: 1. What is a conspicuous property of sulphur? Of copper? Of magnesium?

2. How does this experiment illustrate chemical change?

3. What characteristic of chemical change does this experiment illustrate?

Experiment 3 — Mixture and Compound

Materials. — Powdered sulphur, powdered iron (or clean, fine iron filings), dilute hydrochloric acid, carbon disulphide.

Apparatus. — Scales, magnet, lens, test tubes and holder, Bunsen burner, mortar and pestle.

Weigh about 4 gm. of powdered sulphur on a piece of paper on the scales (see Introduction §8A). Weigh about 7 gm. of powdered iron (or clean, fine iron filings) on another paper.

a. Note and record their conspicuous properties. Try the effect of a magnet on each by moving it along the under side on the paper. Record the result.

Put a pinch of each in separate test tubes, add a little dilute hydrochloric acid, and warm gently. Note and record the result in each case, especially the odor of the gas from the tube containing the iron.

Put a pinch of each in separate test tubes, add about 5 cc. of carbon disulphide, and shake well. (**Caution.** Carbon disulphide catches fire readily. Do not use carbon disulphide near a flame.) Note and record the result.

Mix the sulphur and iron thoroughly by grinding them together in a mortar. Divide the mixture into two equal portions. Use one in **b**, and the other in **c**.

b. Examine the mixture from **a** with a lens. Can you detect sulphur and iron? Try the effect of a magnet on some of the mixture, and state the result.

Divide this portion into two parts. Put one part in a test tube, and add dilute hydrochloric acid. Warm the acid mixture gently until there is evidence of action, note the odor and compare with the odor from the iron and acid in **a**. Put the other part in a test tube, add 5 cc. of carbon disulphide, shake well, let it settle, pour the liquid into a dish, and stand the dish in the hood. When the carbon disulphide has evaporated, examine the solid product. What is it?

c. Put the other half of the mixture from **a** in a test tube, attach the holder, and heat (Fig. 3). When the mass begins to glow, take the test tube out of the flame. Heat again intensely for a few minutes. Let the tube cool, hold it over the mortar, break off the lower end with the pestle. Remove the glass, grind the product, and use it in **d**.

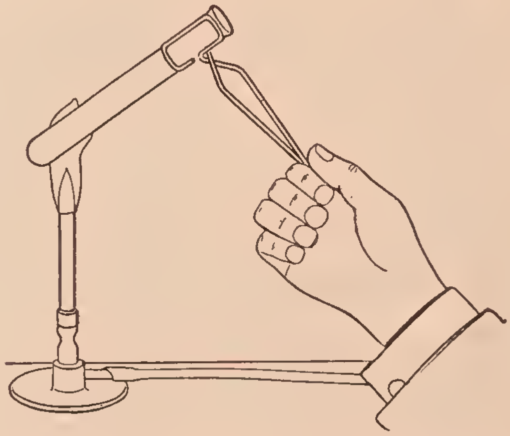


FIG. 3. — Heating a mixture of iron and sulphur in a test tube

d. Examine the powder from **c** with a lens. Is iron or sulphur detected? Note and record the effect of a magnet.

Put a pinch in a test tube, add a little hydrochloric acid, note the odor of the gas, and pour the contents immediately into a waste jar in the hood. Compare the odor of the gas with similar tests (*e.g.* in **a**). Is there evidence of iron? Of a new substance?

Put a pinch in another test tube, add 5 cc. of carbon disulphide, and shake well. As soon as the solid has settled, pour the liquid into a dish, stand the dish in the hood, and let the liquid evaporate. Is any sulphur left in the dish?

Answer: 1. What are some characteristics of a mixture? Of a compound?

2. Is the product in **c** a mixture or a compound? Why?

3. If the product in **c** had been weighed, how would its weight be related to the weight of the sulphur and iron?

4. How does this experiment illustrate the first characteristic of chemical change? The second characteristic?

Experiment 4 — Compound and Elements

MATERIALS. — Oxide of mercury, joss stick (or small splint of wood).

APPARATUS. — Test tube clamped to iron stand (Fig. 4), Bunsen burner.

Put a little oxide of mercury (the same as mercuric oxide) on the end of a narrow piece of paper creased lengthwise, and slip the powder into a test tube (Fig. 5). The powder should nearly fill the round end of the test tube. Hold the test tube in a horizontal position, shake it to spread the powder into a thin layer, and then clamp the test tube as in Fig. 4.

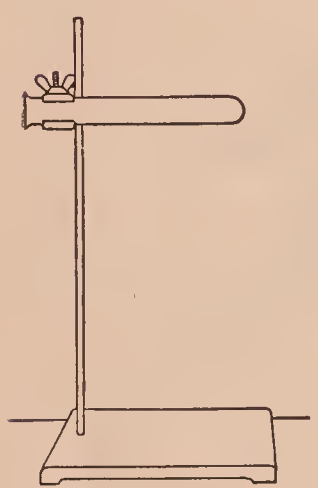


FIG. 4. — Apparatus for decomposing oxide of mercury

a. Heat the whole test tube at first; then heat intensely the part that contains the substance. After heating for several minutes insert a glowing joss stick well into the test tube. Observe and describe the change. The change is due to oxygen. If there is no change, heat intensely again and insert the glowing joss stick.

b. Examine the deposit on the upper part of the tube. What is it? If you are in doubt, scrape out a little upon a piece of paper and examine it. (NOTE. — Some unchanged oxide will probably be left; throw it in the waste jar.)

Answer: 1. To what class of substances does mercuric oxide belong?

2. To what class does the product from **a** belong? From **b**?

3. Into what substances can mercuric oxide be decomposed?

OXYGEN

(Practical Chemistry, pp. 12–22, §§ 15–30)

Experiment 5 — Preparation of Oxygen — Short Methods

MATERIALS. — Lead dioxide, barium dioxide, potassium chlorate, sodium peroxide, hydrogen peroxide, dilute sulphuric acid, potassium permanganate solution, joss stick.

Apparatus. — Test tube clamped to an iron stand (as in Fig. 4), burner.

(Note. — Hereafter the pieces of apparatus provided each pupil will not be included.)

a. Put a little lead dioxide into a test tube and proceed with the heating as in Exp. 4. If more convenient, the substance may be heated as in Exp. 3 **c** (see Fig. 3). Test with a glowing joss stick. State the result.

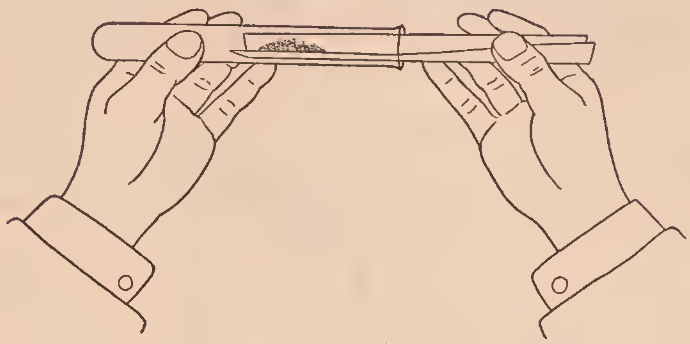


Fig. 5. — Putting a powder into a test tube — first step

b. Proceed as in **a**, using barium dioxide. State the result.

c. Proceed as in **a**, using potassium chlorate. State the result.

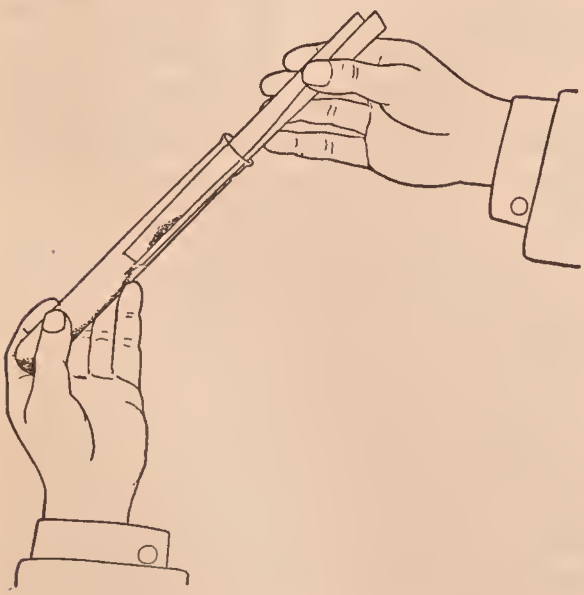


Fig. 5 A. — Putting a powder into a test tube — second step

d. Fill a test tube nearly full of water and stand it in the test tube rack. Obtain from the Teacher a little sodium peroxide on a creased paper, cautiously slip the sodium peroxide into the water, and put a glowing joss stick into the gas in the upper part of the test tube. State the result.

e. Fill a test tube half full of fresh hydrogen peroxide, add half the volume of dilute sulphuric acid, shake, and then nearly fill the test tube with potassium permanganate solution. Immediately test the escaping gas with a glowing joss stick. State the result.

Experiment 6 — Preparation and Properties of Oxygen — Long Method

Materials. — 5 gm. of potassium chlorate, 5 gm. of manganese dioxide, joss stick, sulphur, piece of charcoal fastened to one end of a copper wire (30 cm. long), wad of iron thread ("steel wool").

APPARATUS. — As in Fig. 6. *A* is a large test tube (20 cm. or 8 in.) provided with a one-hole rubber stopper, to which is fitted a short glass tube *B*; the latter is connected by the rubber tube *C* with the delivery tube *D*. *E* is a pneumatic trough with a support for a collecting bottle.

I. Preparation. — Weigh the potassium chlorate on the scales on a piece of paper creased lengthwise, and slip it into the test tube; do the same with the manganese dioxide. Shake the test tube until the chemicals are thoroughly mixed. Hold the test tube in a horizontal position and roll or shake it until the mixture is spread along about one half of the tube. Insert the stopper with its tubes, and clamp the test tube to the iron stand, as shown in Fig. 6, taking care not to crush the tube or disturb the contents. The end of the delivery tube *D* should rest on the bottom of the trough under the hole in the support. Be sure there are no leaks. Before proceeding, ask the Teacher to inspect the apparatus.

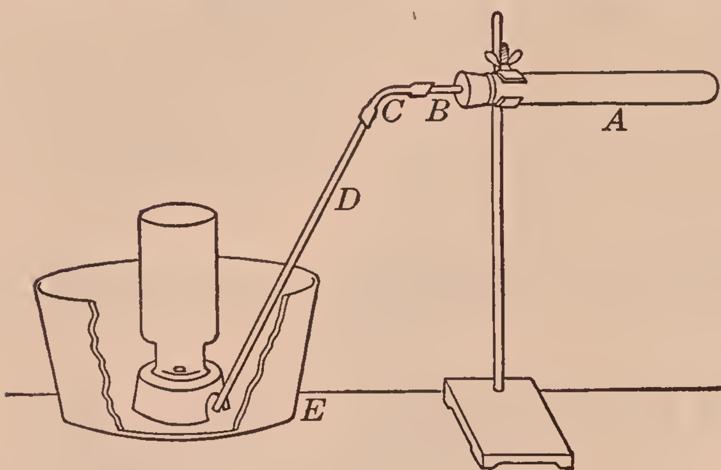


FIG. 6. — Apparatus for preparing oxygen (See also Fig. XIX)

Add water to the pneumatic trough *E* until the hole in the support is covered. Fill one bottle *full* of water, cover it with a piece of filter paper, invert it in the trough, remove the paper, and stand the inverted bottle upon, or near, the support (Fig. XIX). Fill three more bottles and have them ready to replace the one filled with gas.

Heat the test tube gently with a small Bunsen flame about 10 cm. (4 in.) high. Move the flame slowly along the test tube, taking care not to heat the tube too long in one place nor too near the rubber stopper. As soon as the gas bubbles regularly through the water, slip the inverted bottle over the hole in the support. The gas will rise in the bottle and force out the water. If the gas comes off too rapidly, remove the flame for an instant; if too slowly, increase the heat; if not at all, examine the stopper and the rubber connecting tube for leaks, and adjust accordingly.

When the first bottle is full of gas, remove it, cover it tightly with a piece of filter paper, and stand it (mouth upward) upon the desk. Invert another bottle in the trough, remove the paper, and slip the bottle over the hole. Fill it with oxygen. Fill all the bottles in the

same way. When the last bottle of gas has been collected, immediately remove the end of the delivery tube *D* from the water. (NOTE. — After the test tube is cool, the contents can be removed with warm water.) Perform **II** at once.

II. Properties. — **a.** Thrust a glowing joss stick into one bottle, and observe the result. Remove the joss stick, make it glow again, and repeat as many times as possible. How does the glowing joss stick change? Does oxygen burn?

b. Put a small piece of sulphur in the deflagrating spoon, and heat it until the small, blue flame of burning sulphur is seen. Then lower the spoon into a bottle of oxygen. Notice any change in the flame. **Very cautiously** waft a little of the contents of the bottle toward the nose. Of what does the odor remind you? (As soon as the results are conclusive, remove the spoon and plunge it into the water in the trough to extinguish the burning sulphur. Cover the bottle with a piece of filter paper.)

c. Heat the charcoal (fastened to the wire) long enough to produce a faint glow, then lower it into a bottle of oxygen. Observe the result.

d. Twist one end of the copper wire (used in **c**) firmly around the wad of iron thread, heat the ends of a few strands for an instant, and quickly lower it into a bottle of oxygen. The iron should change conspicuously. Observe the result.

REQUIRED EXERCISES. — 1. Write a brief account of Exp. 6 **I** in your notebook.

2. Write a brief account of Exp. 6 **II**, answering all questions.

3. State some physical properties of oxygen, *e.g.* color, solubility in water.

4. Describe the chemical conduct of oxygen.

5. (Optional.) Sketch the apparatus used to prepare oxygen.

Experiment 7 — Oxidation of Copper

APPARATUS. — Evaporating dish, test tube fitted with a cork.

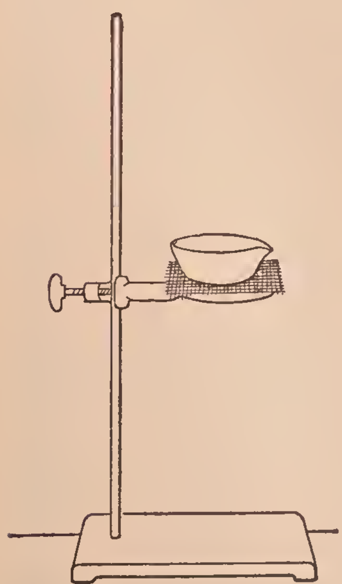


FIG. 7. — Evaporating dish on a gauze-covered ring for oxidation of copper

Put about 4 gm. of clean copper borings in an evaporating dish and stand the dish on a gauze-covered ring attached to an iron stand (Fig. 7). Heat the dish carefully but intensely

about ten minutes. Then heat the contents of the dish directly with the free flame for about five minutes. Describe any marked change in the copper.

When the dish is cool, transfer the contents to a test tube, cork tightly, and save for Exp. 23. (NOTE. — The dish can be cleaned by warming dilute nitric acid in it.)

Answer: 1. What chemical compound was formed?

2. What elements combined?

3. What general name is given to this kind of chemical change? What special name?

Experiment 8 — Heating a Known Weight of a Metal in Air

MATERIAL. — Zinc dust.

APPARATUS. — Crucible block (Fig. 8), covered crucible (Fig. 9).

Copy the form of RECORD (see below) in your notebook. When you weigh, take the notebook to the balance (or scales) and enter all weights in the proper place as soon as the weighing is made. Do this hereafter in all experiments which involve weighing.

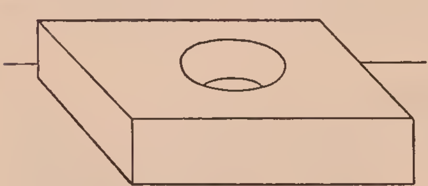


FIG. 8. — Block for carrying a crucible

Clean and dry a porcelain crucible and cover. Place the covered crucible on the crucible block (Fig. 8), and carry it to the balance (or scales); always use this block in carrying the crucible to and from the balance (or scales). Weigh the covered crucible (see Introduction § 8). Enter the weight in the proper place in the RECORD.

RECORD

Wt. of crucible, cover, and zinc	gm.
Wt. of crucible and cover	______ gm.
Wt. of zinc	gm.
Wt. of crucible, cover, and contents after heating	gm.
Wt. of crucible and cover	______ gm.
Wt. of contents after heating	gm.
Wt. of zinc	______ gm.
Change in weight	gm.

Crease a slip of paper lengthwise, pour about 3 gm. of zinc dust into the crease, slide the zinc dust into the crucible (Fig. 5), and weigh accurately (including the cover). Enter the weight.

Place the covered crucible on the triangle supported by a ring on an iron stand (Fig. 9). Heat gently with a low flame to avoid breaking the crucible. Gradually increase the heat until the flame is just above the bottom of the crucible. Lift the cover occasionally by grasping the ring firmly with the forceps. If the zinc glows and a smoke escapes, cover the crucible at once to prevent loss. Heat for about twenty minutes.

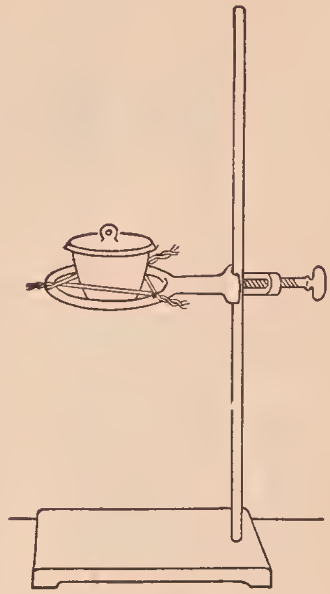


FIG. 9. — Covered crucible supported on a triangle

Cool the crucible gradually by moving the flame slowly beneath it. As soon as the crucible is cool, weigh. Enter the weight, and complete the RECORD.

Show the final weight to the Teacher before throwing away the contents of the crucible. (NOTE. — The crucible can be cleaned with dilute hydrochloric acid.)

Answer: 1. What is the name of the product?
2. What is the result of heating a known weight of a metal in air?
3. To what is the difference in weight due?

Experiment 9 — Slow and Rapid Oxidation

(Demonstration Experiment)

MATERIALS. — Powdered potassium nitrate, charcoal, phosphorus-tipped match, bottle of oxygen, iron thread, phosphorus (for **c**), magnesium (for **d**), bottle of oxygen (for **d**).

APPARATUS. — As in Fig. 10, iron pan.

a. Lay a piece of charcoal on an iron pan, heat it with a direct flame, and when hot, cautiously sprinkle powdered potassium nitrate upon the hot surface. Stand back as soon as the chemical action begins. Observe the action, especially its violence and rapidity, also the effect on the charcoal.

b. Rub the head of a phosphorus-tipped match with the finger in a dark place, and observe and describe the result.

c. Teacher's Experiment. Put a small piece of phosphorus (Care!) in an evaporating dish nearly full of water, cut off a thin slice, return the rest of the phosphorus to the bottle, and place the slice on an iron pan or a brick. Stand back, and observe the result.

d. Teacher's Experiment. Grasp one end of a short piece of magnesium firmly with the forceps, hold the other end in the flame for an instant, then remove it, and let the magnesium burn in the air. In a similar way light another piece and quickly thrust it into a bottle of oxygen. Compare the results. In which case was oxidation more rapid?

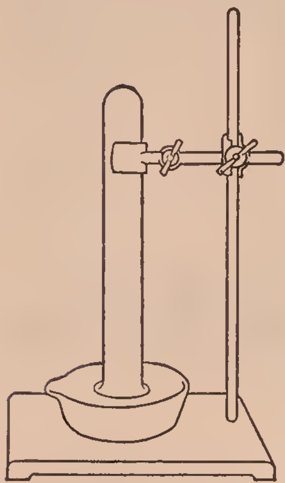


Fig. 10. — Apparatus for showing slow oxidation

e. Fill a test tube half full of iron thread, add 10 cc. of water, and moisten the iron. Cover the open end, and invert the test tube in a dish nearly full of water. Slip a rubber band upon the test tube to mark the height of the water, and clamp the test tube to the iron stand so that the open end touches the bottom of the dish (Fig. 10). Let the whole apparatus stand undisturbed for a day or two, taking care to keep the open end of the test tube covered with water. Observe and explain the final result.

Experiment 10 — Air and Combustion

Materials. — Wood, paper, candle.
Apparatus. — Two blocks of wood, lamp chimney.

a. Set fire to a small piece of wood, drop it while burning into a bottle of air, and cover the bottle with a block of wood. Observe and state the final result.

b. Proceed as in **a**, using a piece of paper and another bottle. Observe and state the final result.

c. Attach a short candle to a block of wood with melted candle wax. Stand a lamp chimney tightly over the lighted candle. How is the flame affected?

d. Hold the chimney a short distance (1 cm. or 0.5 in.) above the lighted candle. Does the candle continue to burn? Why? Keep the chimney in the same position and cover the top with a block of wood. What is the result? Why?

Answer: 1. What is your conclusion from these experiments about the relation of air to combustion?

2. Apply 1 to oxygen.

3. How could the conclusion in 2 be verified by a simple experiment in the laboratory?

CARBON AND ITS OXIDES

(Practical Chemistry, pp. 25–37, §§ 31–47)

Experiment 11 — Distribution of Carbon

MATERIALS. — Sand, wood, cotton, starch, sugar, candle.
APPARATUS. — As in Fig. 11; block of wood.

a. Cover the bottom of the crucible (*A*) with sand. Put in a small piece of wood, a wad of cotton, and a lump of starch. Fill the crucible with dry sand, and slip it into the ring of an iron stand (Fig. 11). Heat intensely until the smoking ceases (about 20 minutes). While the crucible is heating, proceed with **b**, etc. When the crucible is cool, pour the contents upon a block of wood or an iron pan. Separate the lumps from the sand. Examine and compare them with the original substances. What is the residue?

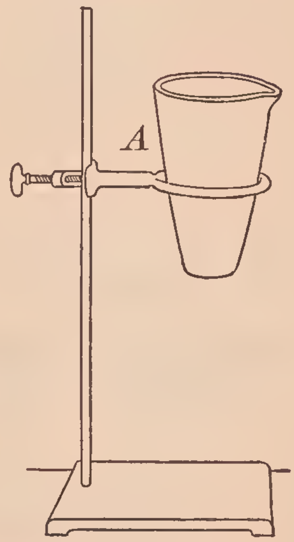


FIG. 11. — Apparatus to show the distribution of carbon

b. Heat a little sugar in a test tube until the smoking ceases. What is the most obvious solid product?

c. Close the holes at the bottom of a lighted burner, and hold a glass tube in the upper part of the flame long enough for a thin deposit to form. Examine it. What is it? State its source.

d. Hold a glass tube in the flame of a candle which stands on a block of wood, and note the result. Compare with **c**. What is the deposit?

Experiment 12 — Combustion and Carbon Dioxide

MATERIALS. — Copper wire, charcoal, limewater, wood, paper, denatured alcohol, gasolene.
APPARATUS. — Bent tube as in Fig. 12 for *h*.

a. Wind one end of a copper wire around a small lump of charcoal, hold it in the flame until the edges glow, and then lower it into a bottle. Let it remain for a minute or two, then remove. Fill the bottle one-fourth full of fresh limewater, cover with the hand, and shake. Observe and state the result.

b. Recall and record the result of adding limewater to a bottle which was held over a burning candle. (See Exp. 1.)

c. Burn wood (*e.g.* a match) and paper in separate bottles and test as in **a**. State each result.

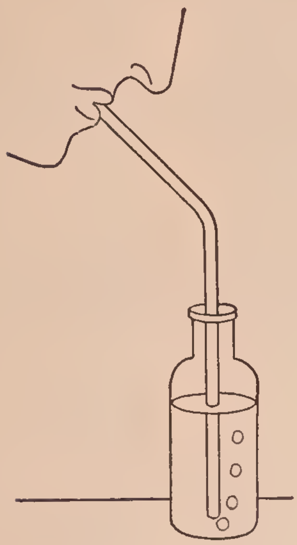


Fig. 12. — Testing the breath

d. Put several drops of denatured alcohol in an evaporating dish, set it on fire, and hold a bottle over the flame. Test as in **a**. State the result.

e. Proceed as in **d**, using gasolene instead of alcohol (Care !). State the result.

f. Hold a bottle over a low Bunsen flame for a minute or so, and then test as in **a**. State the result.

g. Optional. Draw smoke through limewater, and state the result.

h. Exhale the breath through a glass tube into a bottle half full of limewater (Fig. 12). Describe the result. What gas does the breath contain?

Answer: 1. Is carbon dioxide a product of combustion in each case?

2. What are two tests for carbon in a compound?

Experiment 13 — Fermentation and Carbon Dioxide

(Demonstration Experiment)

Materials. — Karo or molasses, yeast cake, limewater, kerosene.
Apparatus. — Bottles and bent tube as in Fig. 13.

Put 20 cc. of karo or molasses in a 250 cc. bottle (*A* in Fig. 13), add 175 cc. of water, and mix well. Grind one-fourth of a fresh yeast cake to a paste with about 10 cc. of water, add it to the solution and shake well. Fill the bottle *B* half full of limewater and cover this solution with a little kerosene (to protect it from the air). Connect as in Fig. 13 and let the apparatus remain a day or more where the temperature is 25° to 30° C.

Examine the liquid in *B* at intervals. What is the evidence that carbon dioxide is a product of fermentation?

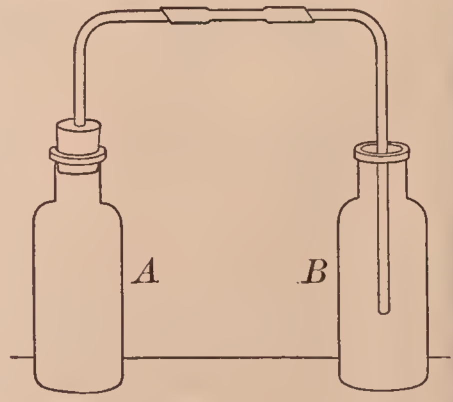


Fig. 13. — Apparatus to show the relation of fermentation and carbon dioxide

Experiment 14 — Preparation and Properties of Carbon Dioxide

MATERIALS. — Calcium carbonate, dilute hydrochloric acid, candle fastened to a wire, joss stick, calcium hydroxide solution.

APPARATUS. — As in Fig. 14. *A* is a 250 cc. bottle provided with a two-hole stopper, through which passes the dropping tube *B* and the right-angle bend *C*; the tube *D* (15 cm. or 6 in.) is attached to the bent tube by the rubber tube *E*.

The dropping tube is made as follows: Cut off the top of a thistle tube about 2.5 cm. (1 in.) below the juncture of the stem and cup, and heat the sharp ends a minute or two in the flame; when cool, slip a *thick-walled* rubber tube (5 cm. or 2 in. long) over one end of the stem, attach a pinch-clamp to the rubber tube, and connect the tube with the cup, taking care to have the ends of the glass tubes as close together as possible. If properly constructed, the cup will remain upright when full of liquid.

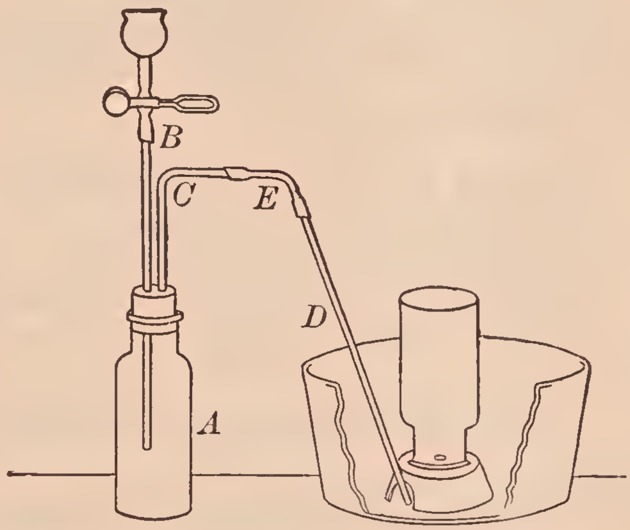


FIG. 14. — Apparatus for preparing carbon dioxide

NOTE. — Instead of the apparatus shown in Fig. 14, one of the simpler forms shown in Fig. 15 may be used; in these the end of the thistle tube must be beneath the acid.

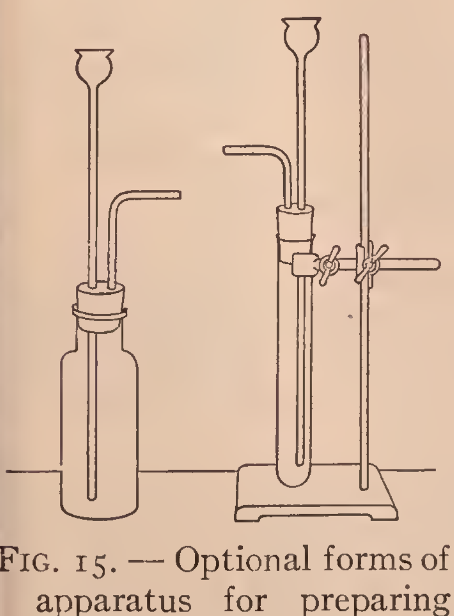


FIG. 15. — Optional forms of apparatus for preparing carbon dioxide

I. **Preparation.** — Put about 20 gm. of calcium carbonate into the bottle, and arrange the apparatus as in Fig. 14. Fill the pneumatic trough with water, fill a bottle with water, cover with filter paper, invert, stand it on the support, and remove the paper (see Fig. XIX). Fill three other bottles and have them ready. Introduce enough dilute hydrochloric acid through the dropping tube *B* to cover the calcium carbonate. Carbon dioxide will be evolved at once.

Collect four bottles, cover tightly with filter paper, and stand aside till needed. Proceed at once with **II.**

II. Properties. — **a.** Plunge a blazing joss stick several times into a bottle. Observe and state the result.

b. Lower a short, lighted candle into a bottle of air, and quickly invert a bottle of carbon dioxide over it, holding the bottles mouth to mouth. Observe and state the final result.

c. Pour a little calcium hydroxide solution into a bottle of carbon dioxide, cover with the hand, and shake vigorously. Describe and explain the result.

d. Fill a bottle of carbon dioxide one-third full of water, cover it tightly with the hand, and shake vigorously. Invert the bottle, still covered, in the pneumatic trough and remove the hand. Observe and state the result.

NOTE. — As soon as **d** is performed wash the acid from the marble and save the solid for other experiments.

Answer: 1. Describe briefly the preparation of carbon dioxide.

2. What do **a** and **b** show about the relation of carbon dioxide to combustion?

3. What does **b** show about the relative weights of carbon dioxide and air?

4. What does **d** show about the solubility of carbon dioxide?

Experiment 15 — Beverages and Carbon Dioxide

(Demonstration Experiment)

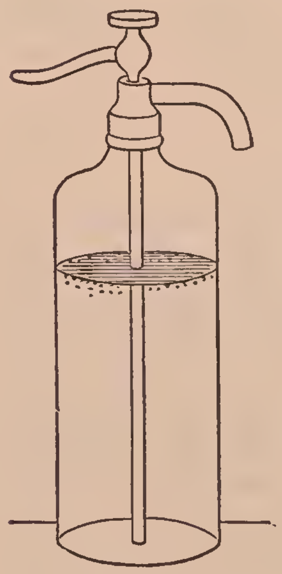


FIG. 16. — A siphon of water charged with carbon dioxide

MATERIALS. — Siphon of charged water, bottle of ginger ale (or similar beverage), calcium hydroxide solution, joss stick.

APPARATUS. — As in Fig. 16, bent tube fitted to a one-hole stopper, beaker (or bottle.)

a. Draw off some charged water from a siphon (Fig. 16) into a beaker (or bottle), and let it stand a minute or two. Then show the presence of carbon dioxide in the beaker (or bottle).

b. Remove the metal cap from a ginger ale bottle, pour off a little of the liquid, and insert the rubber stopper with its tubes and arrange the apparatus so that the outer end rests on

the bottom of an empty beaker (or bottle). Let the whole remain undisturbed a few minutes, and then show that the beaker (or bottle) contains carbon dioxide.

c. Proceed as in (*b*) with the same bottle, but fill the beaker (or bottle) half full of calcium hydroxide solution, and have the outer end of the tube dip beneath the surface of the solution (Fig. 17). If necessary, warm the bottle of ginger ale.

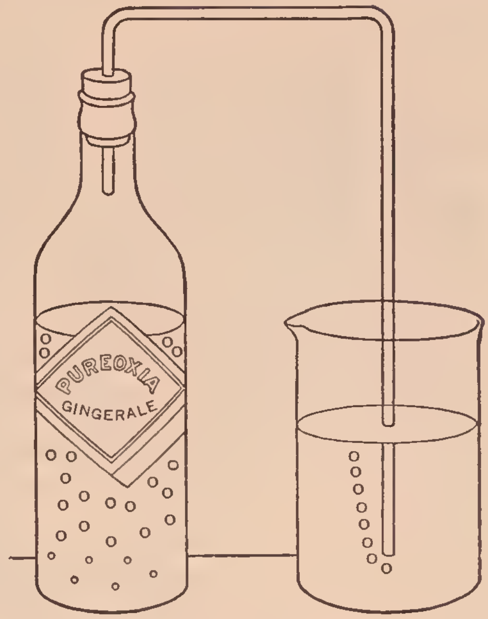


FIG. 17. — Testing the gas from a charged beverage

Answer: 1. What is the evidence of carbon dioxide in these experiments?

2. What is the evidence that the carbon dioxide was under pressure in the siphon and the bottle? In which was the pressure greater?

Experiment 16 — Plants and Carbon Dioxide

(Demonstration Experiment)

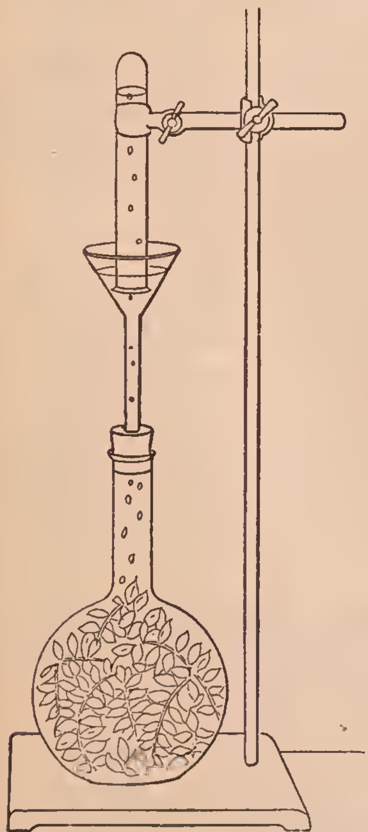


FIG. 18. — Experiment to show the relation of carbon dioxide to plants

MATERIALS. — Fresh green leaves, water saturated with carbon dioxide, joss stick.

Proceed as in the author's *Practical Chemistry*, bottom of page 31. Use the apparatus shown in Fig. 18.

REQUIRED EXERCISES. — 1. Describe this experiment.

2. What is the evidence that green plants (*a*) absorb carbon dioxide and (*b*) give off oxygen?

Experiment 17 — Fire Extinguishers and Carbon Dioxide

(Demonstration Experiment)

MATERIALS. — Dilute sulphuric acid, saturated sodium bicarbonate solution.

APPARATUS. — Bottle with one-hole stopper and tubes as in Fig. 20, fire extinguisher (the portable type as in Fig. 19).

a. Add dilute sulphuric acid to a test tube half full of saturated sodium bicarbonate solution and show that the escaping gas is carbon dioxide.

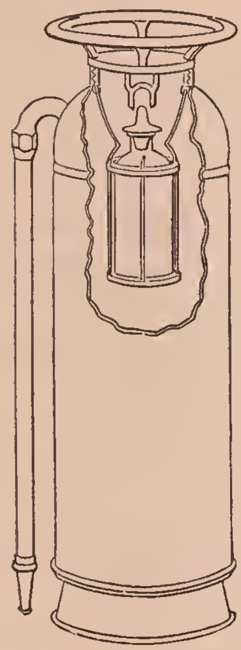


FIG. 19. — Portable fire extinguisher (cut away to show acid bottle)

b. Unscrew the top of a portable fire extinguisher (Fig. 19) and examine the parts, noting especially the opening of the escape tube, bottle of acid, stopper, and collar. Remove a little of the solution, and test it as in a. Replace the cap, take the extinguisher to the roof, yard, or street and show how to use it in extinguishing a small fire.

c. Optional. Make a simple extinguisher like that shown in Fig. 20. The bottle and tubes are those used (as *A-C-E-D*) in the apparatus shown in Fig. 14. The bottle is filled about two-thirds full with saturated sodium bicarbonate solution, the small tube (inside the bottle) contains dilute sulphuric acid and a piece of lead to hold it down after it is lowered into the solution. Connect the tubes with the stopper and push the stopper well down into the neck of the bottle.

Build a small fire in a dish or on some bricks. Hold the end of the tube in one hand, with the other grasp the bottle by the neck, taking care to hold the stopper tightly with the fingers, invert the bottle, and direct the stream upon the fire.

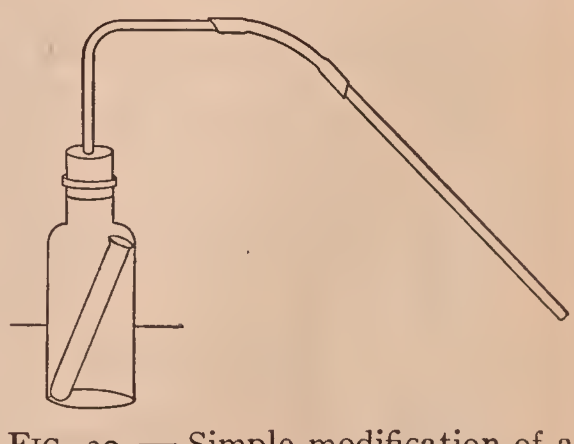


FIG. 20. — Simple modification of a fire extinguisher

Answer: 1. Why are sulphuric acid and sodium bicarbonate used in a fire extinguisher?

2. Why does the liquid flow out of a fire extinguisher with such force?

3. Does a "chemical" fire engine differ essentially from a portable extinguisher? If so, how?

Experiment 18 — Carbon Monoxide

(Demonstration Experiment)

Proceed as in Exp. 142, or postpone until carbon monoxide is studied.

HYDROGEN

(Practical Chemistry, pp. 39–48, §§ 48–57)

Experiment 19 — Preparation of Hydrogen — Short Methods

MATERIALS. — Zinc, magnesium, aluminium, iron, dilute hydrochloric acid, dilute sulphuric acid, sodium hydroxide.

a. Fill a test tube half full of dilute hydrochloric acid, stand it in the rack, and drop in a small piece of zinc. Test the escaping gas by holding a lighted match at the mouth of the test tube. (If the test is not decisive, add more zinc, warm gently, or wait until more gas accumulates in the test tube.) What gas is it? What was its source?

Proceed in the same way with magnesium and iron (in the form of tacks or filings); use separate test tubes, and heat, if the action is slow. Observe the result in each case, and apply the questions asked about zinc.

b. Proceed as in **a**, using dilute sulphuric acid. Observe the result in each case. Answer the questions asked in **a**.

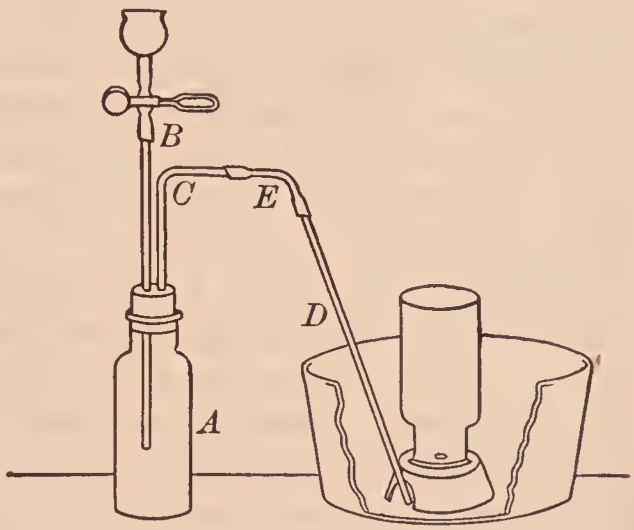


FIG. 21. — Apparatus for preparing hydrogen

c. Roll two or three small, thin pieces of aluminium into a ball, drop it into a test tube, slip in a piece of sodium hydroxide about 2.5 cm. (or 1 in.) long, and add a little water. Warm gently. Observe the result, and test as above. Answer the questions asked in **a**.

Experiment 20 — Preparation and Properties of Hydrogen — Long Method

MATERIALS. — 10 gm. of granulated zinc, dilute sulphuric acid, copper sulphate solution, wax taper.

APPARATUS. — As in Fig. 21. See also Fig. 15 for optional forms.

I. **Preparation.** — Slip the zinc into the bottle (or test tube) — Fig. 21. Insert the stopper with its tubes. Be sure there are no leaks. Fill the pneumatic trough with water as usual, and ad-

just the apparatus so that the end of the delivery tube rests on the bottom of the trough under the hole in the support. Fill the bottles with water, and cover each with filter paper; invert one in the trough, remove the paper, and stand the inverted bottle upon the support (see Fig. XIX).

Put 2 or 3 cc. of copper sulphate solution in the cup, fill with dilute sulphuric acid, and let the acid mixture run into the bottle by pinching the clamp; if the acid does not flow freely down the tube into the bottle, loosen the stopper *for an instant*. (The copper sulphate hastens the chemical change.) The gas will bubble through the water up into the bottle.

Collect and remove four bottles of gas as in the **Preparation of Oxygen** (Exp. 6), taking care to cover each bottle *tightly* with a piece of wet filter paper. If the evolution of gas slackens or ceases, add a little more acid through the dropping tube. Perform **II** at once.

II. Properties. — a. Uncover a bottle for an instant to let a little air in, and then hold a lighted match at the mouth of the bottle. Observe the result.

b. Remove the paper from another bottle and allow it to remain uncovered for three minutes — by the clock. Then show the presence or absence of hydrogen by holding a lighted match at the mouth of the bottle. Observe the result. What property of hydrogen does this experiment show?

c. Stand a covered bottle of hydrogen on the desk, place a bottle of air over it, remove the paper, and bring the mouths of the bottles together. Let them remain in this position for a minute or two, then remove the upper bottle and cover both with wet filter paper.

Remove the paper from one bottle and hold a lighted match at the mouth. Observe the result. Do the same with the other bottle. What property of hydrogen does this experiment show?

d. Invert a covered bottle of hydrogen, remove the paper, and quickly thrust a lighted taper up into the bottle. Withdraw the taper slowly. Then insert and withdraw it several times, and observe carefully (1) if the hydrogen burns, (2) if so, where, and (3) if the taper burns both inside and outside the bottle. Feel of the neck of the bottle; describe and explain. What properties of hydrogen are shown by this experiment?

NOTE. — As soon as **II** is completed, wash the zinc several times, and save it for other experiments.

REQUIRED EXERCISES. — 1. Write a brief account of Exp. 20 **I**.
2. Write a brief account of Exp. 20 **II**, answering all questions.

3. State the conspicuous physical properties of hydrogen.

4. What is a test for hydrogen?

5. Why was there an explosion in **a**? Why none in **d**?

6. Does hydrogen support combustion?

7. (Optional.) Sketch (from memory, if possible) the apparatus used to prepare hydrogen.

Experiment 21 — Interaction of Water and Sodium

(Demonstration Experiment)

Materials. — Sodium, tea lead (or wire gauze).
Apparatus. — Test tube clamped over dish as in Fig. 22.

Caution. — Sodium is a dangerous substance. It should be handled cautiously and used strictly according to directions. Small fragments obtained for experiments should be protected from water by a mortar or dish. If any sodium is left from an experiment, it must not be thrown into the refuse jar, but returned to the bottle.

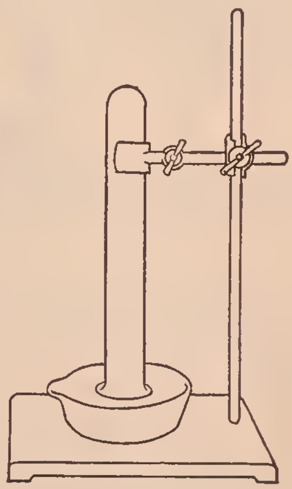


Fig. 22. — Apparatus for collecting the gas liberated by the interaction of water and sodium

Fill an evaporating dish two-thirds full of water. Fill a test tube full of water, cover and invert it, and clamp it as shown in Fig. 22. Wrap a small piece of clean sodium loosely in a piece of dry tea lead about 5 cm. (2 in.) square, make two or three small holes in the tea lead, and slip it under the test tube. (Wire gauze may be used instead of tea lead.) A gas will rise in the test tube. Proceed similarly with additional pieces of sodium and *dry* tea lead until the test tube is full of gas. Then unclamp it, keep it mouth downward, and hold a lighted match at the mouth. Observe the result immediately, especially at the mouth of the tube. What is the gas? What was its source?

Experiment 22 — Burning Hydrogen

(Demonstration Experiment)

Materials. — 20 gm. of granulated zinc, dilute sulphuric acid, copper sulphate solution, platinum wire (optional), small bottle.

Apparatus. — As in Fig. 23. The platinum tip is shown (about actual size) in Fig. 24. Directions for making the platinum tip may be found

in the author's *Experimental Chemistry*, page 340. If platinum is not available, a piece of capillary glass tubing about 5 cm. (2 in.) long may be used.

Caution. — Perform this experiment with extreme care, since a mixture of hydrogen and air explodes violently if ignited.

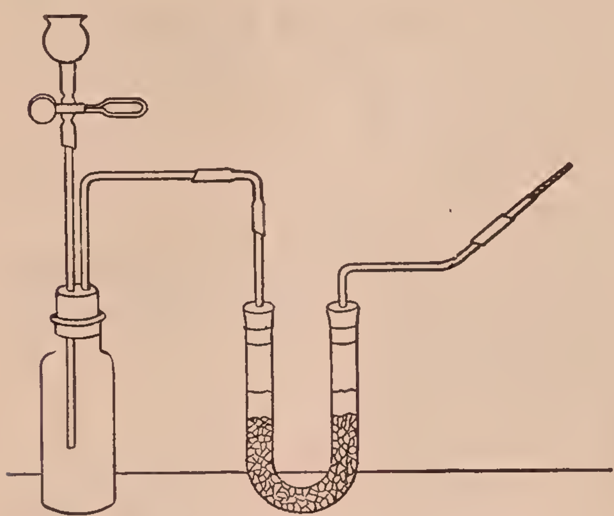


FIG. 23. — Apparatus for burning hydrogen

Put the zinc in the bottle (Fig. 23). Fill the U-tube two-thirds full of calcium chloride, put a wad of cotton upon the solid, insert the stopper in each arm, and connect the U-tube with the generator and the exit tube. Examine all joints to be sure they are tight. Extinguish all flames in the vicinity, and proceed exactly according to directions.

Introduce through the dropping tube about 25 cc. of dilute sulphuric acid containing 5 cc. of copper sulphate solution. Acid may be added slowly after the evolution of gas begins, but no air should be introduced.

Let the gas bubble through the acid two minutes, then attach the rubber connector and the capillary glass tube (or the platinum tip) to the end of the exit tube, leaving a short space between the ends of the two glass tubes so the rubber tube may be compressed suddenly, if necessary. Let the gas run half a minute to drive air out of the tip (Fig. 24).

FIG. 24. — Platinum tip

Slip a small test tube over the tip, and when it is full of hydrogen gas remove the test tube (still inverted or closed with the thumb), take it a few feet away from the generator, and hold a lighted match at the mouth; if an explosion results, collect another test tube and test again, repeating until the gas lights with only a faint noise and burns quietly at the mouth of the tube. Then light the hydrogen at the tip, and observe at once the faint flame.

a. Show that the flame is very hot by holding a match or platinum wire over it.

b. Hold a small, dry bottle over the flame in such a position that

the tip of the flame is just inside the bottle. Note the deposit inside the bottle. Remove the bottle, and extinguish the flame at once by pinching the rubber connector. Examine the inside of the bottle. What is the deposit? Explain its formation.

Answer: 1. What is the product of burning hydrogen?
2. How does this experiment illustrate oxidation? Combustion?

Experiment 23 — Reduction of Copper Oxide by Hydrogen

Materials. — Copper oxide, 10 gm. of granulated zinc, dilute sulphuric acid, copper sulphate solution.

Apparatus. — As in Fig. 25. The parts lettered *A*, *B*, *C*, *D*, *E* constitute the hydrogen generator used in Exp. 20. *F* is a large test tube fitted with a two-hole stopper; the delivery tube *E* passes through one hole and extends nearly to the bottom of the test tube. The right-angle tube *G* passes just through the other hole; the tube *G* is lengthened by the rubber tube *H*.

While the parts of the apparatus are being collected and arranged put the copper oxide prepared in Exp. 7 in an evaporating dish, stand the dish on a gauze-covered ring attached to an iron stand (Fig. 7), and heat gently. (If Exp. 7 was omitted, use 5 gm. of copper oxide.) Slip the copper oxide into the *dry* test tube *F* (Fig. 25), hold the tube in a horizontal position and tap it gently to spread the solid into a thin layer. Connect this test tube with the rest of the apparatus, and clamp it into the proper position, taking care not to crush the tube. Put the zinc into the bottle *A*.

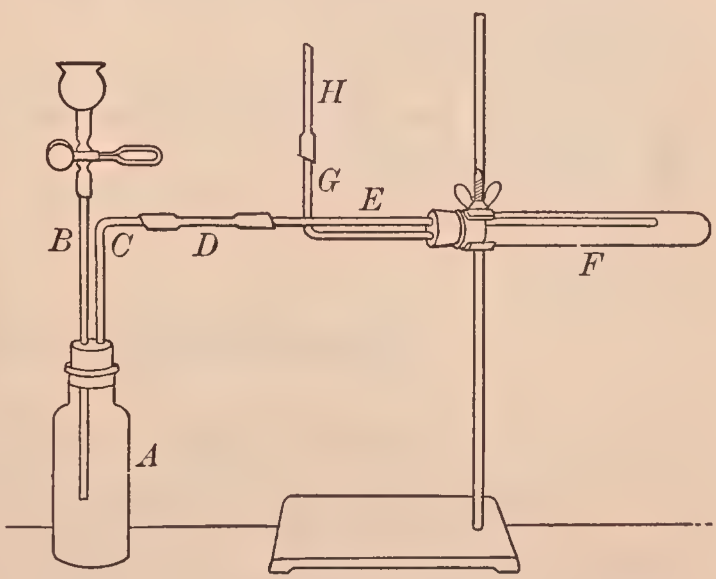


Fig. 25. — Apparatus for the reduction of copper oxide by hydrogen

Ask the Teacher to inspect the apparatus, and do not proceed until permission is given. After obtaining permission, put 2 cc. of copper sulphate solution into the cup, fill the cup nearly full with dilute sulphuric acid, pinch the clamp, and let about half the acid run into

the generator bottle. If the hydrogen does not bubble freely, let more acid run in, taking care to keep a little acid in the cup. Add enough acid to keep the gas flowing steadily through the apparatus for at least two minutes before lighting the Bunsen burner.

Heat gently the lower part of the test tube where the copper oxide is located. *Do not let the flame come near the rubber tube H.* The gas must flow slowly through the apparatus during the heating; if it does not (as you can tell by the bubbles in the bottle or by smelling the gas at the end of the rubber exit tube), introduce more acid. If the test tube *F* should break, pinch the rubber tube *D* an instant to cut off the flow of hydrogen, and then extinguish the Bunsen burner flame.

Continue to heat until a marked and permanent change is observed inside the test tube *F*. Then stop heating, and extinguish the Bunsen burner flame *at once*. Note the two products in the test tube (disregarding any unchanged copper oxide). What is each product?

Required Exercises.— 1. Describe briefly the whole experiment, and sketch the apparatus.

2. What chemical compound was formed in *F*?

3. How was the copper oxide changed? What special name is given to this kind of change?

4. Recall Exp. 7 (Oxidation of Copper). In Exps. 7 and 23, what was oxidized, what was reduced, and what substances accomplished the oxidation and the reduction?

5. Summarize in a few words how Exps. 7 and 23 illustrate oxidation and reduction.

MEASUREMENT OF GASES

(Practical Chemistry, pp. 50–57, §§ 58–66)

Experiment 24 — Weight of a Liter of Oxygen

Note. — This Experiment may be postponed until the pupil has acquired more experience in the laboratory.

Object. — To find the weight of a certain volume of oxygen, reduce this volume to standard conditions, and calculate the weight of 1 liter of oxygen. (Note. — See Introduction, § 8, for directions about weighing.)

Materials. — Potassium chlorate, manganese dioxide, calcium chloride, glass wool or shredded asbestos.

Apparatus. — As in Fig. 26. *A* is a test tube attached to the bent tube *F* by a rubber stopper. *B* is a large bottle (2500 cc.) to be filled with

water; it is provided with a two-hole rubber stopper, through which pass F and C, the latter being connected with a rubber tube C' to which is attached the short glass tube G. A Hofmann screw is attached at the point E. Another bottle (2500 cc.) D serves to catch the water forced over from B through CC' by the oxygen generated in A. The hook S of aluminium wire permits A to be hung from the balance beam in weighing. Thermometer, barometer.

Copy the form of RECORD, as given below, in the notebook. Enter all weights and volumes in the proper place as soon as the weighing and measuring are done.

Fill the space 1 in A with a mixture of equal weights of powdered manganese dioxide and powdered potassium chlorate (Fig. 26). The mixture should be dried before use by heating it in an oven to about 110° C. Push glass wool, or shredded asbestos (previously ignited to a red heat), into the space 2 in A. Put small lumps of calcium chloride into 3 and glass wool into 4. Push the stopper well into the test tube. Wipe A carefully with soft paper. Weigh AF accurately on the balance and enter the weight in the proper place in the RECORD. Weigh the empty, dry, clean bottle D to a decigram on the scales, and record the weight.

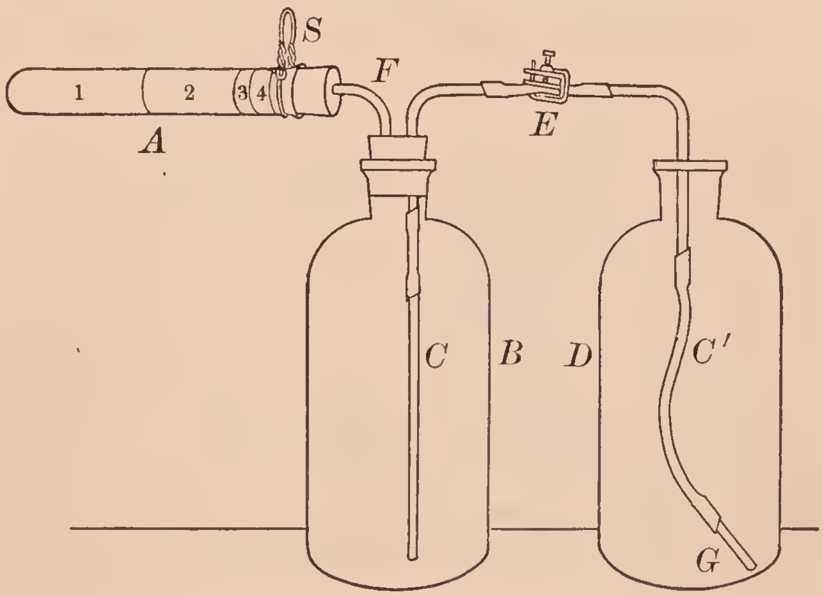


FIG. 26. — Apparatus for finding the weight of a liter of oxygen

Fill B with water nearly to the neck. Fill CC' with water and tighten the Hofmann screw to prevent the water from running out. Insert F into the stopper of B. Push the stopper into the bottle, slowly at first, then hard; if water rises in F, loosen the screw at E slightly, remove A, and blow gently into F to force the water back into B. When properly adjusted, the water should be in B and CC' but not in F. Replace A, taking care not to crush the thin glass by pushing it too hard upon its stopper. *Open the screw at E.* If the apparatus is tight, little or no water will flow out. It should be adjusted until air tight. *Leave the screw open.*

Heat A gently with a low flame, keeping the flame back of the space 2. The liberated oxygen will force the water from B into D. Heat A just hot enough to cause a gentle flow of water into D. When B is about half empty, stop heating. While A is cooling sufficiently to weigh, stand a thermometer in D; also read the barometer. When A is cold, raise B until the water is at the same level in B and D, pinch C' tight and remove it from D. Read and remove the thermometer.

Dry D on the outside, if necessary, and then weigh it on the scales; record the weight. The gain in weight (in grams) of D gives the volume of oxygen liberated (since 1 gm. of water = 1 cc.).

Weigh AF on the balance; record the weight. Its loss in weight is the weight of the oxygen that passed into B.

Record

Weight of tube AF before heating	gm.
Weight of tube AF after heating	______ gm.
Weight of oxygen (W)	gm.
Weight of bottle D and water	gm.
Weight of bottle D empty	______ gm.
Weight of water	gm.
Volume of water	cc.
Observed volume of oxygen (V')	cc.
Temperature (t)	° C.
Pressure read on barometer (P')	mm.
Pressure caused by water vapor (a)	______ mm.
Corrected pressure	mm.
Corrected volume of dry oxygen (V)	cc.
Corrected volume of dry oxygen expressed in liters (Vl) . .	l.
Weight of 1 liter of oxygen	gm.

Correct the observed volume (V') of oxygen for temperature (t), pressure (P'), and pressure of water vapor (a). That is, reduce the observed volume to the volume (V) it would occupy, if it were at 0° C., 760 mm., and in the dry state (*i.e.* free from water vapor). Water vapor exerts a pressure. Hence the pressure for which the observed volume (V') must be corrected is the observed pressure (P') minus the pressure due to the water vapor (a) in the gas (see § 74 in the author's *Practical Chemistry*). This complete correction is made by this formula: —

$$V = V' \times \frac{273}{273 + t} \times \frac{P' - a}{760}$$

The values for a at different temperatures are given in the Table in the Appendix.

Since 1 liter contains 1000 cubic centimeters, then $V \div 1000$ is the actual volume of liberated oxygen expressed in liters (Vl). The weight of liberated oxygen (W) is found by subtracting the weight of AF after heating from its weight before heating. And finally the weight of 1 liter of oxygen in grams is found by dividing the weight of liberated oxygen by its volume, *i.e.* $W \div Vl$.

WATER — HYDROGEN PEROXIDE

(Practical Chemistry, pp. 59–84, §§ 67–95)

Experiment 25 — Water in Food and Other Substances

a. Heat a small piece of meat in a dry test tube. Hold the open end of the test tube lower than the closed end, and take care not to burn the substance. What substance is liberated?

b. Proceed as in **a**, using a dry test tube in each case and a small piece of the following: Potato, apple, cranberry, celery, bread, cracker. Observe and state the result in each case.

c. Proceed as in **b** with wood, soft coal, fresh grass or leaves, hay, raisins or other kinds of dried fruit. Observe and state each result.

d. How would you find the approximate per cent of water in bread, potato, or meat? Before proceeding, submit the details to the Teacher. Compare the result with the per cent given in the author's *Practical Chemistry*, § 377.

Experiment 26 — Purification of Water

Materials. — Water (100 cc.) rendered turbid with fine clay; cotton, sand, powdered charcoal, alum solution, ammonium hydroxide. For **d** bad smelling water, chlorine water.

Apparatus. — Two funnels, test tube fitted with a cork (for **d**).

a. Put a loose plug of cotton in the apex of a funnel, fill the funnel half full of sand, pour 25 cc. of the turbid water on the sand, and catch the filtrate in a test tube. (Meanwhile do **b**, etc.) Compare the filtrate with the sample. State the result.

b. Proceed as in **a**, using fine wood charcoal instead of sand. Compare the filtrates from **a** and **b** with the sample. State the result.

c. Fill a large test tube about four-fifths full of the turbid water. Add about 5 cc. of alum solution and mix well. Then add about 10

cc. of ammonium hydroxide, and mix well again. Let the mixture stand undisturbed several minutes. Compare the upper liquid with the sample and with the filtrates from **a** and **b**. State the result.

d. Optional. — Add 2 cc. of chlorine water to a test tube nearly full of bad smelling water, cork, shake well, and then compare with the sample. State the result.

Experiment 27 — Distillation of Water — Short Method

MATERIALS. — Copper sulphate and barium chloride solutions, ammonium hydroxide.

APPARATUS. — As in Fig. 27. *A* and *B* are large test tubes, and *C* is a 250 cc. bottle.

Put about 15 cc. of water in the test tube *A*, add 2 or 3 cc. of copper sulphate solution (to color the water), and slip in two short pieces of glass tubing (to prevent "bumping"). Arrange the apparatus as in Fig. 27. *B* is empty and *C* should be about three-fourths full of cold water.

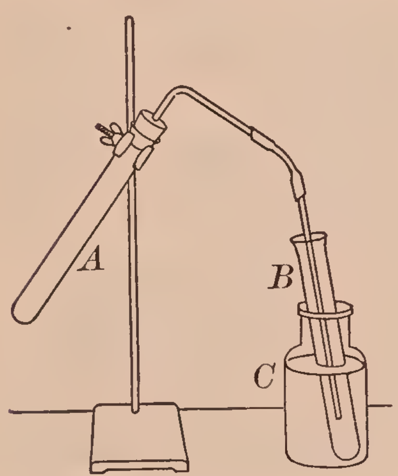


FIG. 27. — Apparatus for distillation of water

Heat the water in the test tube *A* to boiling. The steam passes into the test tube *B* and is condensed by the cold water in the bottle *C*. Continue to heat until about 10 cc. has collected. Compare the color of the distillate in *B* with the copper sulphate solution. State the result. Test half of the distillate for a sulphate by adding barium chloride solution (see Exp. 28 **d** (2)). Test the rest for copper by adding ammonium hydroxide. If copper is present, the solution will become deep blue. State each result.

Experiment 28 — Preparation and Properties of Distilled Water

MATERIALS. — Water containing a little dirt, calcium chloride, and sodium sulphate; potassium permanganate, silver nitrate, barium chloride, and ammonium oxalate solutions.

APPARATUS. — Liebig condenser, etc., as in Fig. 28.

I. Preparation. — For the Teacher. Fill the flask *A* half full of the water containing the three impurities mentioned above, add a

few short pieces of glass tubing to insure even boiling, and connect with the condenser at *B* as shown in Fig. 28. Attach the inlet (lower) tube *C* to the faucet, fill the condenser slowly, and regulate the current so that a small stream flows continuously from the outlet tube *D* into the sink or waste pipe.

Heat the liquid in *A* gradually to boiling, and then regulate the heat so that the boiling is not too violent. Reject the first 5 or 10 cc.

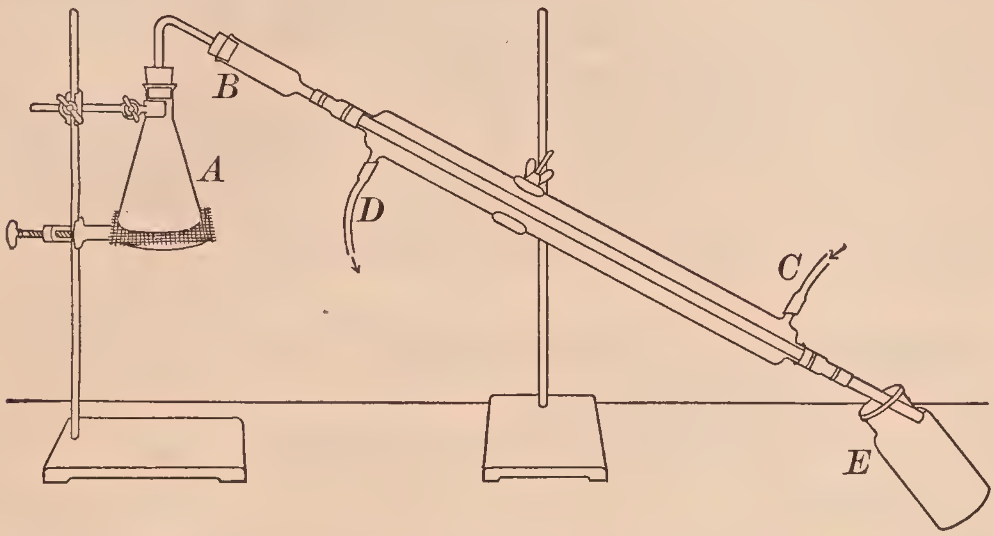


FIG. 28. — Liebig condenser arranged to distil water

of the distillate; they may contain impurities. As the distillate collects in the clean receiver *E*, proceed with the tests as in **II.**

II. Properties. — For the Class. **a.** Taste of the distilled water. Compare with faucet or well water.

b. Test distilled water for dissolved gases by heating a little in a clean test tube. State the result. Compare with faucet water.

c. While the distillate is collecting, test the impure water for organic matter. Put 10 cc. of the impure water in a test tube, add a few drops of concentrated sulphuric acid, and enough potassium permanganate solution to color the mixture a light reddish purple. Mix well by stirring with a glass rod. Grasp the test tube with the test tube holder and heat gently until the liquid begins to boil, taking care to remove the test tube from the flame occasionally to prevent the liquid from spurting out. If organic matter is present, the color of the solution will be changed to brown.

Test in the same way 10 cc. of the distilled water, taking care to use a very clean test tube. Compare the results.

d. Test separate portions (about 10 cc.) of the impure water for different kinds of mineral matter. In a similar way test the distilled water and compare the corresponding tests.

(1) **Chlorides.** — Add a few drops of silver nitrate solution. The white, curdy solid is silver chloride, which is formed by the chemical action between silver nitrate and the dissolved chloride. All soluble chlorides produce the same result. Does the distilled water contain chlorides?

(2) **Sulphates.** — Add a few drops of barium chloride solution. The white, fine precipitate is barium sulphate, which is formed by the chemical action between barium chloride and the dissolved sulphate; its formation is a test for any sulphate in solution. Does the distilled water contain sulphates?

(3) **Calcium (or lime) compounds.** — Add a few drops of ammonium oxalate solution. The white precipitate is calcium oxalate. Its formation serves as a test for dissolved calcium compounds. Does the distilled water contain calcium compounds?

Experiment 29 — Some Physical Properties of Water

MATERIALS. — Ice, copper wire.

APPARATUS. — Test tube with one-hole stopper and short tube (for **b**), thermometer.

a. Wind enough copper wire around a small lump of ice to make it sink in water, slip it into a large test tube nearly full of water, and heat the water quickly near the surface. Observe the effect on the ice. What does this experiment show about the conducting power of water?

b. Fill a large test tube full of water, and insert a one-hole rubber stopper fitted with a short glass tube. Attach the test tube holder and heat the water slowly. Observe any change in the volume as the temperature of the water rises. Then cool the water by holding the test tube in a stream of running water, and observe any change in the volume. What does this experiment show about the effect of heat on the expansion and contraction of water?

c. Fill a large test tube half full of water, clamp it in an upright position to an iron stand, and heat the water to boiling. Hold the bulb of a thermometer in the escaping steam and note the highest temperature reached. Slowly lower the thermometer until the bulb touches the boiling water, note the highest temperature, and then remove the thermometer. Compare the two maximum readings. What is the boiling point of the water? What is the normal boiling point?

d. Fill a 250 cc. bottle half full of water, drop in several pieces of ice, and shake for two or three minutes. Insert the thermometer

until the bulb is immersed, and after a minute or two note the lowest temperature. Apply the questions in **c** to the freezing point.

Experiment 30 — Water Vapor and Steam

(Demonstration Experiment)

Apparatus. — As in Fig. 40, page 64, author's *Practical Chemistry.*

Proceed as in § **71**, next to last paragraph.

Proceed as in § **73**, second paragraph.

Required Exercises. — 1. Describe the experiment.

2. State the result briefly.

3. What is steam?

4. How does water vapor differ from steam?

5. Sketch the apparatus.

Experiment 31 — Water Vapor Exerts a Pressure

(Demonstration Experiment)

Apparatus. — As in Fig. 41, page 66, author's *Practical Chemistry.*

Required Exercises. — 1. Describe the experiment.

2. State the result briefly.

3. To what was the result due?

4. What change in the result would a higher temperature have made? A lower temperature?

5. Sketch the apparatus.

Experiment 32 — Some Chemical Properties of Water

Materials. — Sodium, potassium, zinc sulphate solution, sulphur, calcium oxide.

a. (See **Caution** in Exp. 21.) Fill an evaporating dish half full of water. Obtain three or four small pieces of sodium from the Teacher; place a mortar over the sodium until needed.

Drop a piece upon the water in the dish, stand back and observe the result, waiting for the slight explosion before approaching the dish again; repeat with the rest of the sodium, piece by piece.

When the chemical action is over, stand the dish on a gauze-covered ring attached to an iron stand, and heat until the water is entirely evaporated. Meanwhile proceed with **c**. Make three tests of the residue. (1) Moisten the end of a glass rod, touch the residue with it, and then draw this end across a piece of moistened red litmus

paper. Observe the change in color of the litmus paper; this change is caused by hydroxides — sodium hydroxide in this case.

(2) Moisten the looped end of a clean test wire (Fig. 29), touch the residue with it, and hold the end of the wire in the flame. Observe the color of the flame; it is caused by the sodium in the residue. The production of this color is a *test for sodium.*

(3) Dissolve the rest of the residue in 10 cc. of water, pour a little of the solution into a test tube, add a few drops of zinc sulphate solution, and shake. Observe the result. Now pour the rest of the solution into the test tube and shake well. Observe the result. This is a test for the hydroxide part of sodium hydroxide.

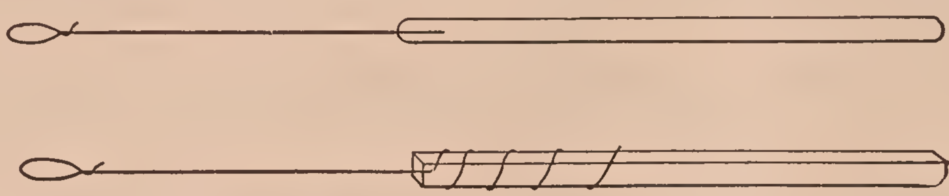


FIG. 29. — Test wires — platinum (upper), nichrome (lower)

b. Teacher's Experiment. — Remove a lump of potassium from the bottle, cut off two or three small slices, and put the rest back in the bottle. Fill a pneumatic trough nearly full of water. Throw a piece on the water and stand back until the slight explosion is heard Note the result, especially the difference from sodium. Repeat with the rest, piece by piece. Test the water (near the surface) with red litmus paper. State the result. Compare with the test in **a** (1). What substance is in the water?

c. (1) Put a little water in a bottle. Set fire to a small piece of sulphur in a deflagrating spoon and lower the burning sulphur into the bottle. Let it burn a minute or two, then extinguish the flame by dipping the spoon into the water. Remove the spoon, cover the bottle with the hand, and shake well. Dip a glass rod into the liquid, draw the moistened end across a piece of blue litmus paper, and observe the change in color. This change in the color of blue litmus is caused by acids; in this case the acid is sulphurous acid, which was produced by the combination of the sulphur oxide and water.

(2) Boil a small piece of calcium oxide with a little water in a test tube. Test with red litmus paper as in (1). If the result is indifferent, put the paper in the test tube and shake well. Observe the result in a minute or two. Compare with (1).

REQUIRED EXERCISES. — 1. State briefly the essential chemical change that took place in **c** (1) and (2).

2. State these chemical changes as equations (using the names of the substances).

Experiment 33 — Solubility of Gases in Water

a. Fill a bottle half full of water, close with the hand and shake vigorously several minutes. Fill a test tube nearly full and warm the test tube gently. What is the immediate evidence of dissolved gas? What effect has increased heat on the dissolved gas?

b. Heat the following in separate test tubes as in **a**: Faucet water, ammonium hydroxide, dilute hydrochloric acid. State in each case the evidence of dissolved gas. (NOTE. — As soon as the observation is made, pour the liquids down the sink and flush it well with water.)

Answer: 1. Does distilled water contain dissolved gases?
2. What gas does soda water contain?
3. In which are gases more soluble, hot or cold water?

Experiment 34 — Solubility of Liquids in Water

MATERIALS. — Alcohol (ethyl or methyl), gasolene, glycerin, aniline, ether, carbon tetrachloride.

a. To a test tube one-third full of water add a little alcohol and shake. Is there evidence of solution? Add a little more and shake well. Add a third portion and shake. Is there still evidence of solution? Draw a conclusion as to the mutual solubility of alcohol and water.

b. Repeat **a**, using successively gasolene, glycerin, aniline, ether, and carbon tetrachloride. Observe the results in each case and conclude accordingly.

c. Tabulate the results of **a** and **b** under the headings Mutual Solubility, Limited Solubility, Very Slight Solubility.

Experiment 35 — Solubility of Solids in Water

MATERIALS. — Sand, calcium sulphate, sodium chloride, potassium permanganate, sodium hydroxide (solid), calcium carbonate (powder).

Put about 1 gm. of the substances in separate test tubes, add 10 cc. of water, and stand the tubes in a rack. Shake well and note the evidence of solubility. In case of doubt, let the solid settle, and transfer half of the clear liquid to an evaporating dish by pouring it down a glass rod (Fig. XIV), and evaporate by heating the dish on a gauze. What is the final evidence of solubility?

Tabulate the difference in solubility as below, using the terms Very soluble, Moderately soluble, Slightly soluble, Insoluble.

Difference in Solubility of Solids

Solvent — 10 cc.	Solid — 1 gm.	Result
Water at temperature of Laboratory	1. Sand	1.
	2. Calcium Sulphate	2.
	3. Sodium Chloride	3.
	4. Potas. Permanganate	4.
	5. Sodium Hydroxide	5.
	6. Calcium Carbonate	6.

Experiment 36 — Effect of Heat on the Solubility of Solids

Materials. — About 5 gm. each of powdered copper sulphate and potassium chlorate, calcium hydroxide solution for *c*.

a. Label two test tubes, I, II. Put 10 cc. of water into each. To I add 1 gm. of powdered copper sulphate, and to II add 1 gm. of powdered potassium chlorate. Shake each test tube, and then allow them to stand undisturbed until the solid settles. Is there evidence of solubility in each case? (Save for **b**.)

b. Heat I, and add gradually 2 gm. of powdered copper sulphate. Does it all dissolve? Heat II and add 2 gm. of powdered potassium chlorate. Does it dissolve? Add the rest of each solid to the respective tubes, and heat (but do not boil). What effect has increased heat on the solubility of the solids? (Save for Exp. 38.)

c. Fill a test tube half full of clear calcium hydroxide solution, and heat it to boiling. Observe the result. Compare with the cold solution. What effect has increased heat on the solubility of calcium hydroxide? How does the result differ from **b**?

Experiment 37 — Effect of Shape on the Solubility of a Solid

Material. — Crystallized alum.

Apparatus. — 2 large test tubes fitted with corks.

Weigh about 2 gm. of crystallized alum (in one lump, if possible) on the scales, and counterpoise it with a second quantity of equal weight. Pulverize the latter in a mortar. Put each in a test tube, add 25 cc. of water, and insert the cork. Note the time. Shake the tubes gently until the powder has dissolved. Note the time again. Estimate the amount of alum left in the other tube, or, if time permits, continue to shake at intervals until the solid has dissolved, and note the time again.

Compare the times required to dissolve the powder and the crystal. Why does dissolving occur faster in one case than in the other?

Experiment 38 — Saturated Solutions

MATERIALS. — Solutions from Exp. 36 **b**, sodium chloride.

APPARATUS. — Large flask or bottle, hydrometer (specific gravity — direct reading) for liquids heavier than water, tall jar (*e.g.* a 250 cc. graduated cylinder).

a. If the test tubes with contents from Exp. 36 **b** were saved, use them; if not, prepare new solutions.

If the contents of the test tube is not liquid, add a little water, and heat gently until the solid dissolves. Cool each solution quickly by holding the lower end of the test tube in a stream of water. Are crystals formed? Are they formed at once? Are they large or small?

b. Wipe each test tube dry and heat gently until the liquid is clear. Stand the tubes in a rack, and let each solution cool slowly and stand undisturbed until the next laboratory period. Observe the result. Compare the size and general shape of the crystals with those formed in **a**.

c. *Demonstration Experiment.* — Prepare a saturated solution of sodium chloride by shaking about 100 gm. of fine salt with 275 cc. of water in a flask or bottle until no more salt dissolves. Let the undissolved salt settle and carefully pour the clear solution into the tall jar. Take the temperature. Let the hydrometer sink carefully into the solution. When the instrument becomes still, read the number on the scale (on the stem) that is level with the surface of the liquid (Fig. 30). This number is the specific gravity of the solution. Compare the concentration with that read from the solubility curve shown in Fig. 43 on page 72 of the author's *Practical Chemistry*

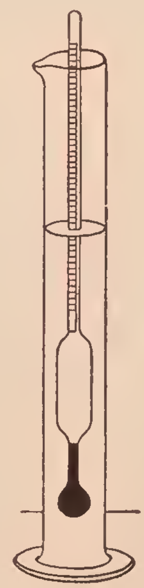


FIG. 30. — Finding the specific gravity of a solution with the hydrometer

Experiment 39 — Solubility of a Given Solid

OBJECT. — To find the number of grams of potassium dichromate dissolved in 100 gm. of water.

MATERIAL. — Potassium dichromate solution (concentration known only to Teacher).

APPARATUS. — Water bath as in Fig. 31.

Copy the form of RECORD in the notebook. Enter all weights in the proper place as soon as weighings are made.

Weigh an evaporating dish on the balance, and enter the weight at once in the RECORD in the notebook. Obtain from the Teacher exactly 25 cc. of the potassium dichromate solution. Pour the solution into the weighed dish. Weigh the dish and contents, and record the weight.

RECORD

Weight of dish and solution	gm.
Weight of dish	________gm.
Weight of solution	gm.
Weight of dish and solid — I gm. II. gm. III	gm.
Weight of dish	________gm.
Weight of solid	gm.
Weight of water (*i.e.* solution — solid)	gm.
Weight of solid dissolved in 100 gm. of water	gm.

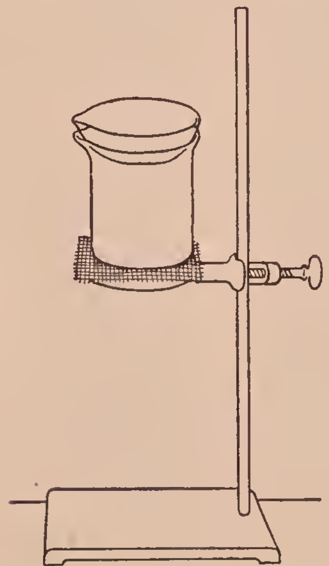


FIG. 31. — Water bath for evaporating a solution to dryness

Stand the dish on a water bath and evaporate the solution to dryness (Fig. 31).

Complete the evaporation by transferring the dish to a gauze-covered ring and heating intensely. When the dish is cool, weigh, and record the weight. Heat again on the gauze, cool, and weigh; if the two weights are the same (or nearly so), accept the first weighing, but if the weights are considerably different, heat intensely (but do not melt the solid), cool, and weigh a third time.

Complete the entries in the RECORD. Calculate the weight of the solid dissolved in 100 gm. of water. Submit the result to the Teacher before throwing away the contents of the dish.

Experiment 40 — Formation of Crystals

MATERIAL. — Powdered alum or borax.
APPARATUS. — Thread, lens.

Prepare a hot, concentrated solution of alum or borax by boiling about 10 gm. of alum or 5 gm. of borax in 10 cc. of water in a large test tube. Pour the solution into an evaporating dish (or a

beaker). Suspend a piece of thread in the solution (as in Fig. 32). Stand the whole aside to crystallize.

Examine at intervals, and when well-shaped crystals have formed on the thread, remove the thread. Dry the crystals carefully with filter paper. Examine them, using a lens if the crystals are small, and observe the properties, particularly the shape, luster, and color. Test a crystal for water of crystallization.

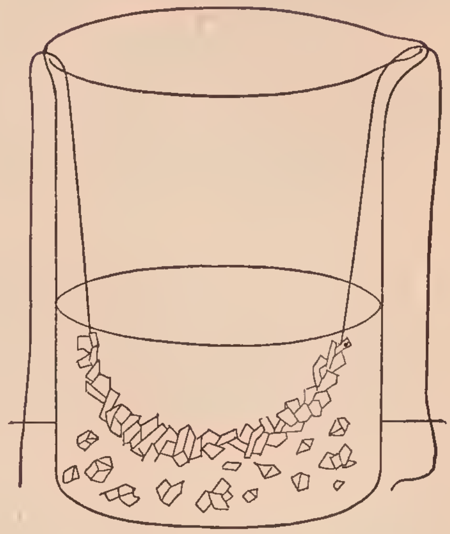


Fig. 32. — Crystallizing alum

Required Exercises. — 1. Describe this experiment.

2. What is the name of the shape of a typical alum crystal? (A borax crystal?)

3. What term describes the luster?

4. Do the crystals contain water of crystallization? Is the amount conspicuously large?

Experiment 41 — Testing for Water of Crystallization

Materials. — Sodium carbonate, potassium dichromate, ferrous sulphate, borax, barium chloride, zinc sulphate, sodium sulphate, calcium sulphate, sodium chloride, potassium nitrate, sugar, magnesium sulphate, potassium bromide.

Test several of the substances for water of crystallization by heating a dry specimen in a dry test tube inclined so that the open end is the lower. Observe in each case the change in appearance of the solid during the heating, relative amount of water liberated (if appreciable), and appearance of the residue. State each result.

Experiment 42 — Per Cent of Water of Crystallization

Object. — To find the weight of water lost by heating a weighed amount of crystallized copper sulphate, and to calculate the per cent of water of crystallization.

Material. — Crystallized copper sulphate (powdered).

Copy the form of Record, as given below, in the notebook, and enter all weights as soon as the weighing is completed.

Clean and dry an evaporating dish and weigh it to a decigram on the scales. Put about 10 gm. of powdered copper sulphate in the dish and weigh to a decigram. Record the weight at once.

Record

Weight of dish and copper sulphate before heating . . .	gm.
Weight of dish	________gm.
Weight of copper sulphate	gm.
Weight of dish and copper sulphate before heating . . .	gm.
Weight of dish and contents after heating	________gm.
Weight of water of crystallization	gm.
Per cent of water of crystallization	per cent

Stand the dish with its contents on a gauze-covered ring attached to an iron stand, heat gently for five or ten minutes, and then intensely until the substance becomes a gray powder. Do not touch the substance, and take special pains not to lose any. Cool slowly and weigh as before. Record the weight at once. Complete the entries in the Record, and calculate the per cent of water of crystallization. Submit the result to the Teacher before throwing away the contents of the dish.

Experiment 43 — Anhydrous Compounds

Materials. — Hydrated (crystallized) copper sulphate and cobalt chloride.

a. Pulverize a little hydrated copper sulphate and note the color. Put it in a test tube, hold the tube horizontal, and spread the powder along the tube. Hold the mouth of the tube slightly lower than the other end, and heat gently. Begin to heat at the closed end and move the tube in the flame so that all the liberated water is finally driven from the tube. Note the color of the anhydrous solid. Let the tube cool. Meanwhile do **b**.

When the tube is cool, cautiously add a little water, and let it run down upon the solid. What effect does the water have on the color of the solid?

b. Proceed as in **a**, using hydrated cobalt chloride.

Answer: 1. What is the difference between a hydrated and an anhydrous compound?

2. What is the color of hydrated copper sulphate? Dehydrated? Anhydrous?

3. As in 2 for cobalt chloride.

Experiment 44 — Efflorescence

Materials. — Sodium carbonate, sodium sulphate, ferrous sulphate, potassium ferrocyanide, barium chloride, magnesium sulphate.

Put a fresh, or a recently broken, crystal of several of the substances on a piece of filter paper, and label each. Let them remain exposed to the air for an hour or more. Describe any marked change in the appearance.

Answer: 1. What does the change, if any, show about the air? About the crystal?

2. To what is the change due?

Experiment 45 — Deliquescence

MATERIALS. — Sodium hydroxide, calcium chloride, potassium hydroxide, magnesium chloride, table salt, zinc chloride, potassium carbonate, sodium nitrate.

Proceed and answer as in Exp. 44.

Experiment 46 — Efflorescence and Deliquescence

(Demonstration Experiment)

MATERIALS. — Crystallized copper sulphate, concentrated sulphuric acid, sodium hydroxide.

APPARATUS. — 4 test tubes fitted with corks, thread, copper or iron wire.

a. Select two pieces of crystallized copper sulphate which will just slip into a test tube. Tie a thread around each piece. Put 10 cc. of water into one test tube, and 10 cc. of concentrated sulphuric acid into the other, taking care not to leave any drops on the inside of the test tube. Hang a piece of the solid in each test tube and insert the cork tightly (Fig. 33); smear a little vaseline around the upper edge of the test tube containing the acid to make the joint air-tight. Let the test tubes stand in the rack undisturbed for several hours (or until the next laboratory period), and then examine each solid. Compare them with each other and with a sample of the original substance. State the change, if any, in each case; state also the degree of change, if possible. Why do the changes differ in degree? Explain.

FIG. 33. — Solid suspended in a closed test tube to show efflorescence and deliquescence

b. Proceed as in a, using sodium hydroxide. Wind the wire around the solid and attach the wire to the thread. Observe, answer, and explain as in a.

Experiment 47 — Supersaturation

MATERIAL. — Sodium thiosulphate.
APPARATUS. — Test tube fitted with a cork.

Fill a test tube half full of crystallized sodium thiosulphate and add 2 or 3 cc. of water. Warm slowly until all the solid has dissolved. Pour the solution into a warm, clean, dry test tube, insert a cork, and let it stand undisturbed until cool. Note the change in the solution, if any. Drop in a small crystal of sodium thiosulphate and watch for a definite change. What happens? Observe and state the final result.

Answer: 1. What is the difference between a saturated and an unsaturated solution?

2. How could you determine whether a cold solution is saturated, unsaturated, or supersaturated?

Experiment 48 — Qualitative Composition of Water

(Demonstration Experiment)

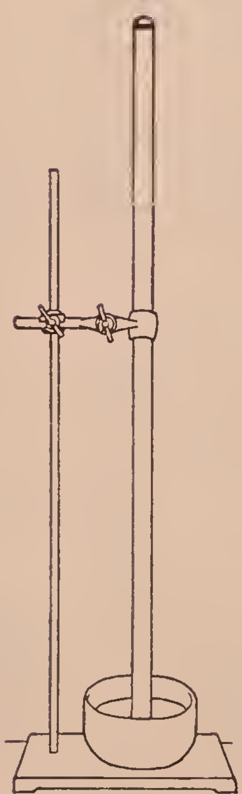


FIG. 34. — Apparatus for showing that oxygen is a constituent of water

MATERIALS. — Chlorine water (see Exp. 60), joss stick.
APPARATUS. — Chlorine tube (tube about 1 m. long closed at one end).

Fill the tube with chlorine water, cover the open end with the thumb or finger, invert the tube, and immerse the open end in a mortar or an evaporating dish, which should be nearly full of chlorine water (Fig. 34). Clamp the tube in an upright position, and stand the whole apparatus where it will receive the direct sunlight for several hours. Bubbles of gas will collect at the top.

When sufficient gas for a test has collected, unclamp the tube, cover the open end with the thumb or finger, invert, and put a glowing joss stick into the gas. Repeat as long as any of the gas remains. State the result. What is the gas?

REQUIRED EXERCISES (Review). — 1. What evidence does the interaction of water and sodium give about the composition of water?

2. Apply Exercise 1 to the burning of hydrogen.

3. Apply Exercise 1 to the reduction of copper oxide.

Experiment 49 — Electrolysis of Water

(Demonstration Experiment)

MATERIALS. — Sulphuric acid, joss stick, taper.
APPARATUS. — Hofmann apparatus.

Fill the Hofmann apparatus (Fig. 35) with water containing 10 per cent of sulphuric acid, so that the water in the reservoir tube stands a short distance above the gas tubes after the stopcock in each has been closed. Connect the platinum terminal wires with a battery of at least three cells (or a street current reduced by suitable resistance).

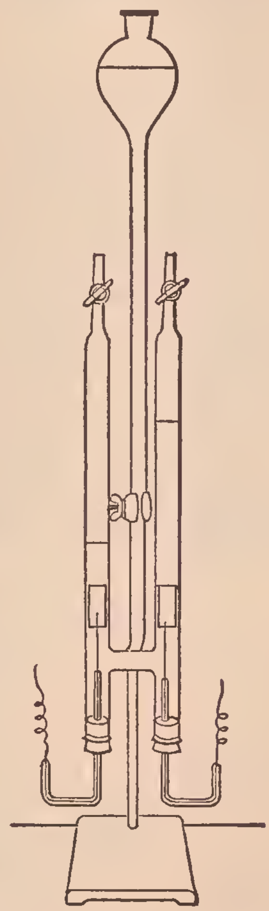


FIG. 35. — Hofmann apparatus for the electrolysis of water

As the action proceeds, small bubbles of gas rise and collect at the top of each tube. Allow the current to run until the smaller volume of gas is 8 to 10 cc.

Measure the height of each gas column. Assuming that the tubes have the same diameter, the volumes are in approximately the same ratio as their heights. How do the volumes compare?

Test each gas. **a.** Open the stopcock of the tube containing the smaller quantity of gas long enough to allow the water (or air) to run out of the glass tip, and then close it immediately. Let out a little gas upon a glowing joss stick, and observe the result. Close the stopcock as soon as the result is seen. What is the gas? Repeat, if gas is available.

b. Open the other stopcock long enough to force out the water (or air) in the glass tip and then close it. Open the stopcock again, let out a little gas slowly, hold a lighted match for an instant at the end of the tip, and immediately thrust a taper into the small and almost colorless flame. Watch for a change in the taper. Close the stopcock as soon as the change is seen. What is the gas?

REQUIRED EXERCISES. — 1. Describe this experiment and sketch the apparatus.

2. What does this experiment show about the composition of water?

3. Compare answer to 2 with answers at the end of Experiment 48.

Experiment 50 — Properties of Hydrogen Peroxide

Materials. — Hydrogen peroxide, manganese dioxide, potassium permanganate solution, lead nitrate solution, hydrogen sulphide (or ammonium sulphide) solution, joss stick.

a. Heat a little hydrogen peroxide, and observe the result. Now add a little powdered manganese dioxide to the heated liquid, and observe the result. Test the escaping gas for oxygen. What is the result?

b. Add several drops of potassium permanganate solution to a little hydrogen peroxide, and observe the result. Is a gas evolved? If so, test it with a glowing joss stick. If not, add more potassium permanganate solution, and then test. What is the gas?

c. Prepare a little lead sulphide by adding a few drops of hydrogen sulphide (or ammonium sulphide) solution to dilute lead nitrate solution. Note the color of the lead sulphide. Shake well, add hydrogen peroxide, and warm gently. Observe the change in color. To what is the change due?

d. Examine the inner end of the cork stopper of a bottle of hydrogen peroxide. Explain the color.

LAWS OF CONSTANT COMPOSITION AND MULTIPLE PROPORTIONS

(Practical Chemistry, pp. 87–100, §§ 96–109)

Experiment 51 — Law of Constant Composition

Object. — To find the weight of oxygen that combines with a definite weight of magnesium.

Material. — Powdered magnesium.

Apparatus. — Porcelain crucible and cover, triangle.

Copy the form of Record (see below) in your notebook and enter each weight as soon as the weighing is made.

Clean and dry the crucible and cover, and weigh both together accurately on the balance. (See Introduction, § 8, for directions about weighing.) Enter the weight in the notebook. Put from 0.4 to 0.5 gm. of magnesium in the crucible, and weigh (with cover) exactly the amount taken. Enter the weight. In carrying the crucible to and from the balance, it should be placed in the crucible block (Fig. 37).

Support the covered crucible as in Fig. 36, and heat for five min-

utes with a flame which touches the bottom of the crucible. Grasp the cover firmly by the ring with the clean forceps, cautiously lift it, and if the magnesium glows, cover the crucible instantly. Repeat this operation at frequent intervals, gradually increasing the heat, until the glow ceases to spread through the mass. Then adjust the cover so that a small opening is left between the cover and the crucible, and heat intensely for ten or fifteen minutes. If the contents has ceased to glow, heat the crucible, uncovered, for five or ten minutes.

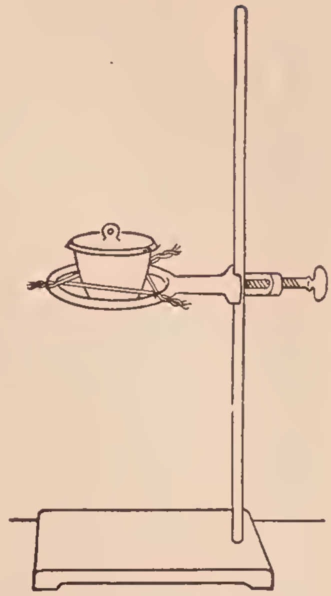


Fig. 36. — Covered crucible supported on a triangle

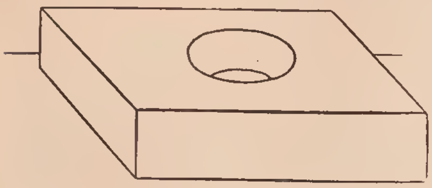


Fig. 37. — Crucible block for carrying a crucible

Cool the crucible gradually. When cool, weigh, and enter this weight as **I** in the proper place.

Heat the uncovered crucible again intensely for five or ten minutes. Cool, and weigh as before; enter this weight as **II**. If the weight is not the same, submit the result to the Teacher.

Record

Wt. of crucible, cover, and magnesium . . . . gm.
Wt. of crucible and cover . . . . ______ gm.
Wt. of magnesium . . . . gm.
Wt. of crucible, cover, and magnesium oxide I gm., II gm., III . . . . gm.
Wt. of crucible and cover . . . . ______ gm.
Wt. of magnesium oxide . . . . gm.
Wt. of magnesium oxide . . . . gm.
Wt. of magnesium . . . . ______ gm.
Wt. of oxygen . . . . gm.

From the weights of the magnesium and the oxygen, calculate the ratio in which the two elements combined. Submit the result to the Teacher before throwing away the contents of the crucible.

Note. — The crucible, if blackened, can be cleaned by heating a little sodium hydroxide solution in it and then washing thoroughly with water.

Experiment 52 — Law of Multiple Proportions

OBJECT. — To find the weight of oxygen liberated by heating known weights of potassium chlorate and potassium perchlorate.

MATERIALS. — Powdered potassium chlorate and potassium perchlorate.

APPARATUS. — As in Exp. 51.

Copy the form of RECORD (see below) in your notebook and enter each weight as soon as the weighing is made.

I. (For one section of the class.) Clean and dry the crucible and cover, and weigh both together accurately on the balance. Put in the crucible about 1.5 gm. of dry powdered potassium chlorate and weigh (with cover) the exact amount taken.

Support the covered crucible as in Fig. 36. Heat with a flame about an inch below the bottom of the crucible. The potassium chlorate melts, begins to decompose, and the oxygen bubbles through the molten mass. Heat about fifteen minutes. Then lower the crucible or raise the burner, until the flame covers the bottom of the crucible. Heat about twenty minutes.

If the flame is too high, the potassium chlorate may spatter and adhere to the inside of the cover. Remove the cover with the forceps occasionally, and if it is coated with potassium chlorate, replace it, and let the crucible cool somewhat. Remove the cover, lay it (ring side down) on a piece of paper on the crucible block (Fig. 37), and loosen the thin layer with a pin. Grasp the cover with the forceps, turn out the pieces upon the paper, and finally scrape them from the paper into the crucible.

When there is no danger of loss by spattering, remove the cover, lay it (ring side down) on the crucible block, and heat the crucible for twenty or thirty minutes.

Let the crucible cool gradually, and when cool, weigh the crucible, cover, and contents, as before. Record the weight as **I** in the proper place.

Heat the uncovered crucible again strongly for five or ten minutes, then cool, weigh as before, and record as **II**. If the weight is the same as after the first heating, proceed with the calculation; if not the same, heat, weigh again, and record as **III**.

From the weights of the potassium chlorate and the oxygen, calculate the per cent of oxygen in potassium chlorate. Do this before throwing away the contents of the crucible.

Record

Wt. of crucible, cover, and potassium chlorate		gm.
Wt. of crucible and cover	______	gm.
Wt. of potassium chlorate		gm.
Wt. of crucible, cover, and contents before heating		gm.
Wt. of same after heating I gm., II gm., III	______	gm.
Wt. of oxygen in potassium chlorate		gm.
Per cent of oxygen in potassium chlorate		

II. (For one section of the class.) Proceed as in **I**, using dry potassium perchlorate. Enter all weights in the Record, and calculate the per cent of oxygen in potassium perchlorate.

III. (For the class.) Calculation. (See § 99 in the author's *Practical Chemistry*.) According to the law of multiple proportions, if we adopt a fixed weight of one part of a compound as a basis, and express the composition in terms of this weight, then the weights of the other part can be expressed in a simple multiple relation. Let us take potassium chloride as the fixed part and oxygen as the multiple part.

Our problem is to find the small whole numbers which show the simple multiple relation between the weights of oxygen in the two compounds potassium chlorate and potassium perchlorate.

a. First, we subtract each per cent of oxygen from 100 (per cent) to find the per cent of the potassium chloride part of each compound. Thus, if we take the exact per cents of oxygen, the per cents of potassium chloride are

60.82 (*i.e* 100 − 39.18) and 53.79 (*i.e.* 100 − 46.21)

b. Second, we adopt 1 as the fixed weight of the potassium chloride part. And we reduce each per cent of potassium chloride to 1, thus,

$$60.82 \div 60.82 = 1 \text{ and } 53.79 \div 53.79 = 1$$

c. But in order to keep the correct proportion of potassium chloride to oxygen (found by our experiments), we must also divide each per cent of oxygen by the corresponding number used in **b**. Thus,

$$39.18 \div 60.82 = 0.644 \text{ and } 46.21 \div 53.79 = 0.859$$

These numbers (0.644 and 0.859) represent the weights of oxygen, if the weight of potassium chloride were 1 in each compound.

d. Our final step is to find the small whole numbers which correspond to 0.644 and 0.859. If we divide 0.644 by 0.859 and express the quotient as a common fraction, we obtain $\frac{3}{4}$. This means that 0.644 and 0.859 are in the same relation as 3 and 4. This means that

the weights of oxygen in the two compounds are in the simple multiple relation 3 : 4.

NOTE. — The per cents of oxygen obtained by individual experiments will probably not give numbers which are in exactly the ratio 3 : 4, but a class average is usually very near 3 : 4.

NITROGEN — AIR

(Practical Chemistry, pp. 102–113, §§ 110–131)

Experiment 53 — Preparation and Properties of Nitrogen

MATERIALS. — Ammonium chloride, sodium nitrite, joss stick, iron thread, sulphur.

APPARATUS. — As in Fig. 38.

I. Preparation. — Weigh 8 gm. of ammonium chloride and 10 gm. of sodium nitrite, put them in the flask, add 50 cc. of water, and shake well. Arrange the apparatus, as in Fig. 38, to collect the gas over water. Fill the bottles with water and invert one in the trough. Have two more bottles ready to replace this one. Fill the cup of the dropping funnel with water, and then ask to have the apparatus inspected by the Teacher.

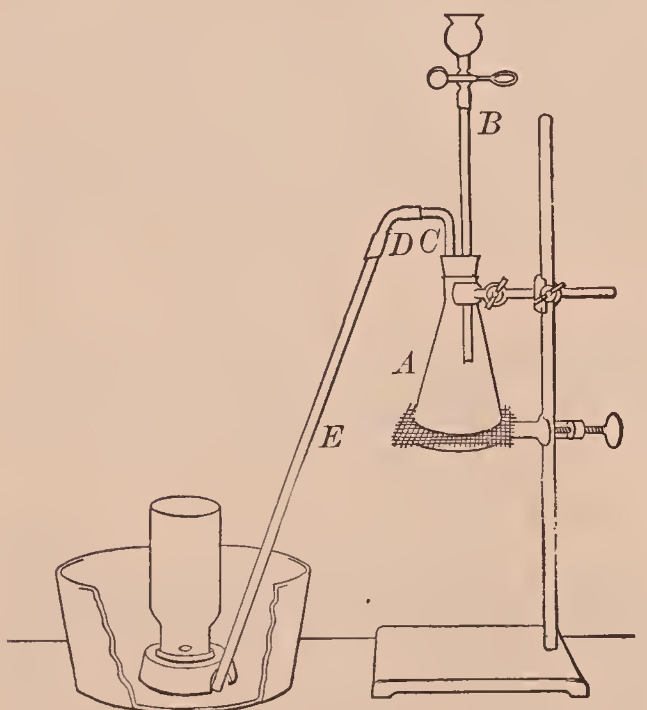


FIG. 38. — Apparatus for preparing nitrogen

Heat the flask gently with a low flame, and as soon as the nitrogen bubbles regularly through the water, slip the bottle over the hole in the support. Heat gently, but enough to keep the gas bubbling slowly through the water. Collect three bottles of nitrogen.

Caution. — If the mixture in the flask begins to froth or the gas comes off too rapidly, remove the flame and let in a little water; if it continues to froth, pinch the clamp to let out the excess of gas. As soon as the frothing lessens, close the clamp and heat gently. Remove the end of the

delivery tube from the water as soon as the last bottle of nitrogen has been collected. Proceed at once with **II.**

II. Properties. — a. Thrust a *blazing* joss stick into a bottle of the gas. Observe and state the result.

b. Put a piece of sulphur in a deflagrating spoon, light the sulphur, lower it into a bottle of nitrogen, and keep it there about half a minute. Observe the result. Withdraw, and observe the result. If the sulphur is still burning, repeat. State the results.

c. Wind one end of a copper wire around a wad of iron thread, heat a few strands, and quickly thrust the glowing iron into a bottle of nitrogen. Observe and state the result.

Required Exercises. — 1. Describe briefly the preparation of nitrogen.

2. Sketch the apparatus.

3. Compare the characteristic properties of nitrogen with those of oxygen found by similar experiments.

Experiment 54 — Transformation of Combined Nitrogen into Ammonia (Test for Combined Nitrogen)

Materials. — Albumin, soda-lime, gelatin, meat, peas, beans, flour, bread, fertilizer.

a. Put a little egg albumin in a test tube and add about five times its bulk of soda-lime. Mix by shaking. Heat gently (in the hood) and hold a piece of wet red litmus paper in the escaping smoke. Observe and state the change in the color of the litmus paper. (One product of the interaction is ammonia gas, but its odor is usually masked by the burning albumin. The nitrogen needed for the ammonia comes from the compound (albumin in this case).)

b. Proceed as in **a**, using gelatin, meat, peas, beans, flour, bread. State each result.

c. Proceed as in **a**, using samples of fertilizers. State each result.

Experiment 55 — Per Cent of Oxygen in Air

Object. — To find the volume of oxygen absorbed from a measured volume of air.

Materials. — Solutions of pyrogallic acid (10 per cent) and sodium hydroxide (50 per cent).

Apparatus. — As in Fig. 39; pneumatic trough half full of water at room temperature, 250 and 25 cc. graduated cylinders. The bottle holds

about 250 cc. and is provided with a tightly fitting one-hole rubber stopper through which passes a glass plug. The plug is made by closing both ends of a glass tube about 10 cm. (4 in.) long, and should fit tight.

Copy the form of RECORD as given below in your notebook and enter each volume as soon as the readings are made.

FIG. 39. — Apparatus for finding the per cent of oxygen in air

First find the volume of the bottle. Fill the pneumatic trough with water and add hot water, if necessary, to raise the temperature to that of the room. Fill the bottle full of water from the pneumatic trough. Push the stopper into the bottle as far as it will go, insert the glass plug until the inner end is flush with the inner surface of the stopper, and then draw a line around the stopper with a lead pencil to mark its position. Remove the plug and then the stopper carefully, to avoid loss of water. Pour water from the bottle into the 250 cc. graduate until the graduate is full (to the 250 cc. mark) or the bottle is empty; read the volume. If the bottle holds more than 250 cc., the rest of the water in the bottle may be poured into the 25 cc. graduate. Record the total volume of the bottle as shown below.

RECORD

a. Volume of bottle . . . . cc.
b. Volume of original solution (total) . . . . ______cc.
  c. Volume of air taken $(a-b)$ . . . . cc.
d. Volume of final liquid . . . . cc.
  e. Volume of water which entered $(d-b)$ . . . . . . cc.
  f. Per cent of water which entered $(e \div c)$ . . . . . .

The per cent of entering water equals the per cent of gas absorbed. Therefore: —

g. Per cent of oxygen in the sample of air . . . . . .
h. Per cent of nitrogen $(100-g)$ . . . .

Measure exactly 10 cc. of pyrogallic acid in the 25 cc. graduate, and pour it carefully into the bottle. Measure also exactly 20 cc. of sodium hydroxide solution, and pour it into the bottle. (**Caution.** — The sodium hydroxide solution is corrosive. Do not spill it on the hands or clothing.) Insert the rubber stopper (with its plug) quickly to the proper mark.

Shake the bottle vigorously for a few minutes, and then invert it

and watch the surface of the liquid for bubbles of air, which will enter if the apparatus leaks. If a leak is detected, ask the Teacher for directions before proceeding. If the apparatus is tight, continue the shaking for about half an hour. During this operation the oxygen is absorbed by the solution.

Place the bottle on its side beneath the water in the pneumatic trough, inclining it slightly so that the lower edge of the bottle rests upon the bottom of the trough and the hole in the stopper is *beneath* the surface of the water. With one hand grasp the bottle firmly by the neck and stopper, and with the other gradually pull out the plug to let the water run in. Water will run in quickly to fill the space left by the oxygen. Take care not to pull out the stopper and not to let any of the solution run out. Be sure also to keep the hole in the stopper constantly beneath the surface of the water. After the water has stopped running in, lift out the bottle, and measure carefully the volume of the liquid in the bottle by pouring it into a graduate. Complete the entries in the RECORD.

NOTE. — This experiment disregards the argon and carbon dioxide in air.

Experiment 56 — Water Vapor in Air

MATERIAL. — Calcium chloride or sodium hydroxide.

Place a piece of calcium chloride or sodium hydroxide on a glass plate or a block of wood, and let it remain exposed to the air for an hour or more. Observe and state the result. How does this experiment show that air contains water vapor?

Experiment 57 — Carbon Dioxide in Air

MATERIALS. — Calcium hydroxide and barium hydroxide solutions.
APPARATUS. — Air blast or suction apparatus (for **b**).

a. Pour 25 cc. of calcium hydroxide solution into a bottle, and let it stand exposed to the air for an hour or more. Examine the surface of the liquid. State and explain the change.

b. Optional. Force, or draw, air through a bottle half full of clear barium hydroxide solution until the liquid is conspicuously changed. Describe and explain the change.

Answer: 1. What do **a** and **b** show about carbon dioxide in air?
2. What does **b** show about the relative amount (large or small)?

Experiment 58 — Testing Air

MATERIALS. — As in Exps. 56, 57.
APPARATUS. — As in Exps. 56, 57.

a. Apply Exps. 56 and 57 to the air in different parts of the school building. Start the tests at the same time to obtain comparable results.

b. Apply Exp. 56 to the air on several days.

c. Apply Exp. 57 to the air in the laboratory, out doors, and in a recitation room which has just been vacated. Proceed with the testing as in **a** (this experiment).

Tabulate the results of the whole experiment.

CHLORINE — HYDROGEN CHLORIDE — HYDROCHLORIC ACID

(Practical Chemistry, pp. 129–141, §§ 142–160)

Experiment 59 — Chlorine — Short Method

MATERIALS. — Potassium permanganate, concentrated hydrochloric acid, wax taper, wad of iron thread, 2 pieces of copper wire about 15 cm. long, colored cloth, piece of newspaper, litmus paper (both colors), cotton, turpentine.

FIG. 40. — Wads of cotton and iron thread for studying the properties of chlorine

Caution. — Do not inhale chlorine. Do this experiment in the hood.

I. Preparation. — Put 5 or 6 crystals of potassium permanganate in each of 4 bottles, add 3 to 5 cc. of concentrated hydrochloric acid, shake, and cover the bottles with a piece of filter paper pressed down to form a loose cap. Chlorine is liberated and will slowly fill the bottles. When the color shows that a bottle is full, proceed at once with it as in **II a.** Use the other bottles when full as directed.

II. Properties. — **a.** Remove the paper from a bottle of chlorine and thrust a blazing wax taper into the gas. Observe the result. Does the gas burn? Does the taper burn? What is the deposit inside the bottle?

b. Using the same bottle as in **a**, hold a lighted wax taper just inside the bottle. Move it up and down slowly. If it goes out, relight it, and con-

tinue. (If a taper is unsatisfactory, use a candle.) Observe the result. The wax consists mainly of compounds of hydrogen and carbon. Is carbon detected? What becomes of the hydrogen? (Suggestion. Compare with **e** below.)

c. Twist one end of a copper wire around a wad of iron thread (Fig. 40), heat the wad for an instant in the flame, and quickly lower it into the second bottle of chlorine. Observe and describe the result, especially the evidence of chemical action.

d. Into the third bottle of chlorine hang (by a wire) pieces of colored cloth, litmus paper (both colors), newspaper, and paper containing writing in lead pencil, ink (black and red) — all moistened with water. Let the whole remain undisturbed for a few minutes (*e.g.* while **e** is being done). Then observe and describe the change. What is bleached? What is not bleached?

e. Twist one end of the copper wire around a wad of cotton, saturate the cotton with turpentine (preferably warm), and lower the cotton into the fourth bottle of chlorine. Observe at once the formation of a white smoke and then the conspicuous result. What two products are formed by the interaction of chlorine and turpentine?

NOTE. — As soon as **II e** has been completed, fill each bottle with water (in the hood) and pour the contents into a waste jar in the hood.

Answer: 1. What is the color of chlorine? Is this gas heavier or lighter than air?

2. What compound was formed in **c**?

3. Were the pencil mark and printing ink bleached in **d**? Why?

4. Of what elements is the compound (or are the compounds) in turpentine composed?

5. What experiments show that chlorine is an active element?

Experiment 60 — Chlorine — Long Method

MATERIALS. — Concentrated hydrochloric acid, 10 gm. of manganese dioxide, and as in Exp. 59 (except potassium permanganate).

APPARATUS. — As in Fig. 41. *A* is a 250 cc. Erlenmeyer flask which stands on a gauze-covered ring; the parts lettered *B*, *C*, *D*, *E* have been used in preceding experiments. *F* is a piece of stiff paper. If desired, the optional apparatus shown in Fig. 42 may be used.

Caution. — As in Exp. 59.

I. **Preparation.** — Slip the manganese dioxide into the flask. Ar-

range the apparatus as shown in Fig. 41. Introduce enough concentrated hydrochloric acid through the dropping tube *B* to cover the manganese dioxide. Heat the flask *A* gently with a small flame. Avoid heating so high that steam or hydrogen chloride is evolved.

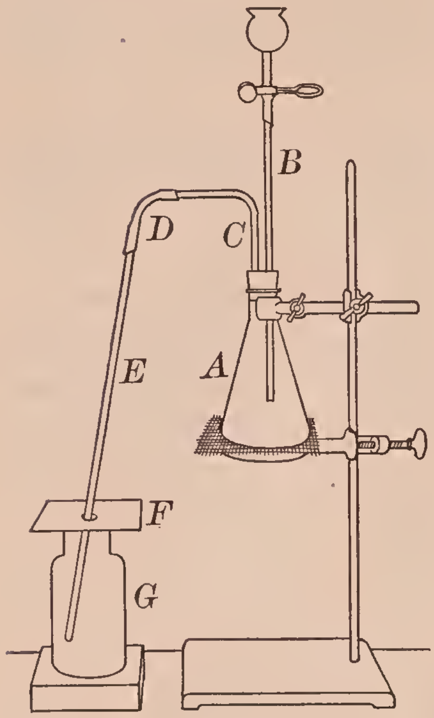


FIG. 41. — Apparatus for preparing chlorine in large quantities

Chlorine is evolved, and passes into the bottle *G*, which should be removed when full (as seen by the color) and covered tightly with a piece of filter paper; the bottle may be easily removed by holding the paper cover *F* in one hand and pulling the bottle *G* aside, bending the whole delivery tube at the same time at the rubber connection *D*. If the evolution of gas slackens, introduce more acid. Collect four bottles, and proceed at once as in **II.**

II. Properties. — a to e as in Exp. 59 a to e.

Experiment 61 — Preparation of Chlorine by Electrolysis (Demonstration Experiment)

MATERIALS. — Sodium chloride, litmus solution, dilute hydrochloric acid.

APPARATUS. — As in Fig. 43. *A* is a small battery jar (or a beaker), the electrodes *E* and *F* are pieces of electric light carbon, and *B* is a piece of glass (or cardboard). A battery of at least six cells, or a reduced street current, is also needed.

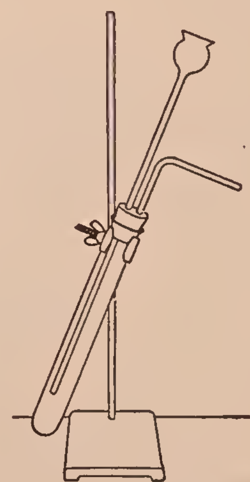


FIG. 42. — Optional apparatus for preparing chlorine

Fill *A* two-thirds full of dilute sodium chloride solution, add a few cubic centimeters of litmus solution, and just enough dilute hydrochloric acid to produce a faint pink color. Slip the partition into the vessel to lessen the diffusion of the liquid. Insert the electrodes and connect them with the battery. Turn on the current. Smell *cautiously* of the gas evolved. Note its effect on the litmus in this compartment. Turn off the current as soon as the observations have been made.

What is the gas? What is the change in color in the other compartment? Explain it (in general terms).

Experiment 62 — Chlorine Water

MATERIALS. — Chlorine water, litmus paper, colored cloth or paper, dark sponge, ink-stained and fruit-stained cloth, gold leaf.

Prepare chlorine water by letting the gas bubble for fifteen minutes or more through a bottle or a test tube nearly full of water.

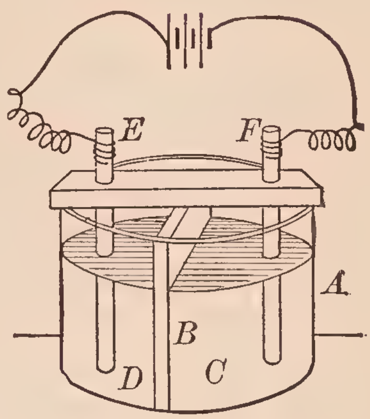


FIG. 43. — Apparatus for preparing chlorine by electrolysis

a. Try the bleaching action of chlorine water on litmus paper, bright colored cloth or paper (that is not decolorized by water alone), a piece of dark sponge, ink-stained and fruit-stained cloth. State the results.

b. Stand a test tube in the rack. Moisten the end of a glass rod, touch it to a small piece of gold leaf, hold the rod with the adhering gold leaf inside a test tube, and wash the gold leaf into the test tube by pouring about 15 cc. of chlorine water down the rod. Remove the rod. Warm the test tube gently and shake until a definite change in the gold is observed. State the final result. Into what has the gold been changed?

Answer: 1. What happens when chlorine water is exposed to the sunlight?

2. What two equations express the reactions in 1?

Experiment 63 — Bleaching

MATERIALS. — Bleaching powder, dilute sulphuric acid, colored cloth for **a**; sodium hypochlorite solution, dilute hydrochloric acid, white cloth for **b**.

APPARATUS. — 3 Beakers (or bottles), glass rod.

a. *Demonstration Experiment.* — Put a little bleaching powder into one beaker and add enough water to make a thin paste. Fill the second beaker one-third full of dilute sulphuric acid, and the remaining beaker one-third full of water.

Press the lower half of the colored cloth into the bleaching powder with the rod, and then into the acid, passing it back and forth several times. Finally wash the cloth thoroughly in the beaker of water, squeeze out the excess of water, and compare the cloth with the sam-

ple. Describe the change in the appearance of the cloth. If the change is not marked, try other kinds of cloth.

b. Let a drop or two of ink fall from a fountain pen upon a piece of white cloth. Lay the cloth over an evaporating dish and pour a little sodium hypochlorite solution drop by drop upon the spot. Then pour slowly a little dilute hydrochloric acid upon the spot. Wash well with water and note the result.

Experiment 64 — Hydrogen Chloride — Short Method

MATERIALS. — Sodium chloride, concentrated sulphuric acid, silver nitrate solution, litmus paper, ammonium hydroxide.

Put a few grams of sodium chloride in a test tube, and add several drops of concentrated sulphuric acid. Hydrogen chloride is evolved.

a. Hold a piece of moist blue litmus paper at the mouth of the test tube. Observe the result.

b. Blow the (moist) breath across the mouth of the tube. Hold a piece of wet filter paper in the gas. Observe the result in each case. Explain it.

c. Hold a glass rod moistened with ammonium hydroxide in the gas. Observe the result. What is the product?

d. Moisten a clean glass rod with silver nitrate solution and hold it in the gas. Observe the result. What is the product? State the result.

Experiment 65 — Hydrogen Chloride and Hydrochloric Acid

MATERIALS. — Sodium chloride, concentrated sulphuric acid, litmus paper (blue), ammonium hydroxide.

APPARATUS. — As in Fig. 41 (or 42).

I. Preparation. — (1) **Hydrogen chloride.** — Put 8 cc. of water into a small bottle or an evaporating dish, cautiously add 10 cc. of concentrated sulphuric acid, and stir until the two are mixed. While this mixture is cooling, weigh 10 gm. of sodium chloride, slip it into the flask, and arrange the apparatus as shown in Fig. 41.

Introduce half of the cold acid mixture into the flask, let it settle through the sodium chloride, and then introduce the remaining acid. Heat the flask gently with a low flame, as in the preparation of chlorine. Hydrogen chloride is evolved, and passes into the bottle *G*, which should be removed when full, as directed under chlorine. (A piece of moist blue litmus paper held near the mouth of the bottle will show when it is full. Let the gas enter a minute or so after the

first test.) Collect three bottles of the gas, cover each tightly, when filled, with a piece of dry filter paper, and set aside for **II**.

(2) **Hydrochloric acid.** — As soon as the third bottle of gas has been collected, put in its place a bottle one-fourth full of water. Adjust the delivery tube *E* so that the lower end is a short distance above the surface of the water. Continue to heat the flask at intervals, and the gas will be absorbed by the water. Shake the bottle occasionally. Meanwhile perform **II**.

II. Properties of hydrogen chloride. — **a.** Insert a blazing joss stick once or twice into a bottle of the gas, and observe the result. Compare the behavior of hydrogen chloride with that of hydrogen, oxygen, carbon dioxide, and chlorine under similar conditions.

b. Hold a piece of wet filter paper near the mouth (or drop it inside) of the same bottle. Observe and describe the result. What is the cause?

c. Invert a bottle of the gas, and stand it in a vessel of water (*e.g.* the pneumatic trough). Shake the bottle up and down, still keeping its mouth under water. Observe any change inside the bottle. What property of the gas does the result illustrate?

Verify the observation by a simple test applied to the contents of the bottle. State the result.

d. Drop into the remaining bottle of gas a piece of filter paper wet with ammonium hydroxide. Describe the result. What is the name of the product?

e. State other properties of hydrogen chloride observed during these experiments, *e.g.* color, odor, density, behavior with moist litmus paper.

III. Properties of hydrochloric acid. — Remove the bottle in which the hydrogen chloride is being absorbed.

a. Determine its general properties, *e.g.* taste (cautiously), action with litmus, and with magnesium (using 10 cc. of the hydrochloric acid). State the results.

b. Add to a test tube half full of the hydrochloric acid a few drops of silver nitrate solution. Describe the precipitate. What is its name? Shake the test tube, filter part of the contents, and expose the precipitate upon the paper to the sunlight. Describe the change in the precipitate which soon occurs. To the remaining contents of the test tube add considerable ammonium hydroxide, and shake. Describe the result.

NOTE. — As soon as **III b** has been performed, add water to the flask, shake well, and pour the contents into a waste jar in the hood.

Experiment 66 — Test for Hydrogen Chloride, Hydrochloric Acid, and Chlorides

a. Recall properties which would serve as a test for (1) hydrogen chloride and (2) hydrochloric acid.

b. Apply the silver nitrate test to a solution of several soluble chlorides in separate test tubes (*e.g.* ammonium chloride, ferric chloride, and calcium chloride). State each result.

NOTE. — It is customary, though not always necessary, to add nitric acid to dissolve compounds other than chlorides which might be formed in testing with silver nitrate.

Experiment 67 — Aqua Regia

MATERIALS. — Gold leaf, concentrated nitric and hydrochloric acids.

Touch a small piece of gold leaf with the end of a moist glass rod, and wash the gold leaf into a test tube by pouring a few cubic centimeters of concentrated hydrochloric acid down the rod. Warm gently. Does the gold dissolve? Wash another piece of gold leaf from a clean glass rod into another test tube with concentrated nitric acid. Warm as before. Does the gold dissolve? Pour the contents of one tube cautiously into the other. Warm gently, if no change occurs. Does the gold dissolve?

Answer: 1. What compound of gold is formed by its interaction with aqua regia?

2. Does chlorine water act like aqua regia on gold?

Experiment 68 — Insoluble Chlorides

MATERIALS. — Silver, lead, and mercurous nitrate solutions.

a. Put about 5 cc. of silver nitrate, lead nitrate, and mercurous nitrate in separate test tubes, and label each tube. Add 5 cc. of dilute hydrochloric acid to each solution, shake, and note the result. Describe each precipitate. Name each.

b. Shake well, and pour about half of each precipitate into separate test tubes. Save the rest of the precipitates for **c**.

Fill each of the three test tubes half full of water, and heat to boiling. Note each result. Which chloride dissolves in hot water?

c. Fill each of the test tubes saved in **b** with ammonium hydroxide. Shake well. Warm gently. Note each result. What is the effect of ammonium hydroxide on each chloride?

d. Optional. Test unknown solutions for (1) a chloride and (2) lead, silver, and mercurous compounds. State each result.

Answer: 1. In what are these three chlorides insoluble?

2. How could the three chlorides be separated from one another?

3. What is a test for (*a*) a soluble chloride, (*b*) an unknown solution supposed to contain a chloride, (*c*) a lead compound, (*d*) a silver compound, (*e*) a mercurous compound, (*f*) lead chloride, (*g*) silver chloride, (*h*) mercurous chloride?

4. How can a chloride be distinguished from a sulphate?

ACIDS, BASES, AND SALTS — NEUTRALIZATION

(Practical Chemistry, pp. 142–146, §§ 161–167)

Experiment 69 — General Properties of Acids

MATERIALS. — Litmus paper (both colors), magnesium ribbon, sodium carbonate.

Fill three test tubes half full of water; add about 5 cc. of dilute sulphuric acid to one, of hydrochloric acid to another, and of nitric acid to the third. Shake the test tubes thoroughly, and label each.

a. Dip a clean glass rod into each acid successively and *cautiously* taste it. Describe the taste by a single word.

b. Dip a clean glass rod into each acid successively and put a drop on both kinds of litmus paper. Note the decided change in color. The change is characteristic of acids.

c. Pour out the acids and replace the hydrochloric and sulphuric acids with dilute acid from the bottle. Omit the nitric acid. Slip a small piece of magnesium ribbon into each test tube. Note the results. If no marked chemical action results, warm gently. Test the most obvious product by holding a lighted match inside of each tube. What gas comes from the hydrochloric and sulphuric acids?

d. Fill a test tube half full of dilute sulphuric acid, have ready a blazing joss stick, add a lump of sodium carbonate to one tube, and test the escaping gas. Do the same with the other two acids. What is the gas?

Experiment 70 — General Properties of Bases

MATERIALS. — Sodium hydroxide and potassium hydroxide solutions, ammonium hydroxide, litmus paper (both colors).

Prepare a very dilute solution of each base as in Exp. 69.

a. Cautiously taste each liquid by touching to the tip of the tongue a rod moistened with each, and describe the result. Compare with acids.

b. Test each solution with litmus paper (both colors). Describe the result. Compare with acids.

c. Rub a little of each undiluted solution from the bottle between the fingers, and describe the feeling.

Experiment 71 — A Property of Many Salts

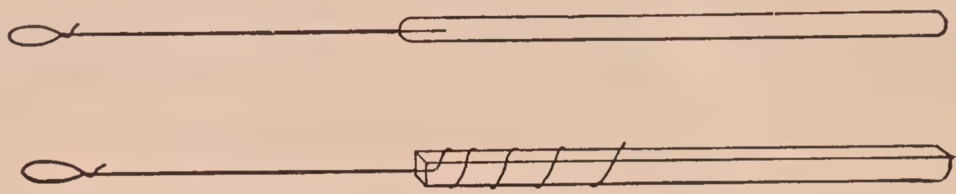


FIG. 44. — Test wires — upper platinum, lower nichrome

MATERIALS. — Litmus paper (both colors), dilute solutions of chemically pure sodium chloride, potassium nitrate, potassium sulphate, barium chloride, potassium chlorate, potassium bromide, and strontium nitrate.

a. Test the solutions with litmus paper. Describe the result in each case. Compare the litmus reaction of salts with the reaction of acids and bases.

b. Dip a clean glass rod into each solution (except barium chloride) successively and cautiously taste it. *Do not swallow the liquid.* Describe the taste.

Experiment 72 — Composition of Acids, Bases, and Salts

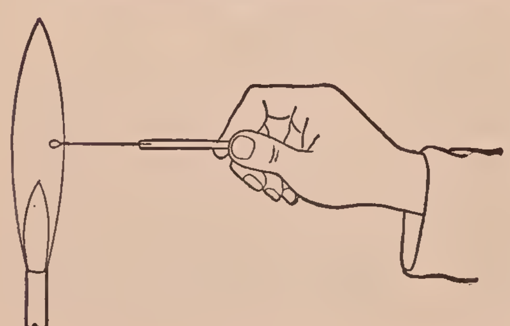


FIG. 45. — Testing for metals by the color of the flame

I. Acids. — a. Recall or devise an experiment to show that hydrogen is a constituent of acids, *e.g.* hydrochloric, sulphuric, acetic.

b. Recall or devise an experiment to show that another constituent of acids is a non-metallic element or group, *e.g.* Cl, SO_4.

II. Bases. — a. Recall or devise an experiment to show that hydroxyl (OH) is a constituent of bases. (See Exp. 32 a (3).)

b. Show by the flame test that a constituent of bases is a metal, *e.g.* sodium, potassium, calcium, barium. Dip a clean test wire (Fig. 44) into each solution and hold the end of the wire in the flame

as in Fig. 45. The flame is colored yellow by sodium, pale violet by potassium, red by calcium, and green by barium. Concentrated calcium hydroxide, or the powdered substance, should be used.

III. Salts. — **a.** Recall or devise experiments to show that a constituent of salts is a metal, *e.g.* sodium, potassium, calcium, barium, silver, lead, mercury (mercurous).

b. As in **a**, also a non-metallic element or group of elements — the same as in **I b**.

Answer: 1. What is a constituent common to acids? To bases?

2. What class of elements, single or in groups, is a constituent of acids? Of bases?

3. What classes of elements, single or in groups, are constituents of salts?

Experiment 73 — Testing for Acids and Bases

MATERIALS. — Lemon juice, vinegar, sweet and sour milk, wood ashes, faucet water, cream of tartar, the juice of any ripe fruit and any unripe fruit, household ammonia, potash, limewater, pickles, jelly, grape juice, lye, "unknowns."

Apply the litmus test to the substances enumerated above. Make a solution of each of the solids before testing. Tabulate the results under the terms, Acid and Basic.

Experiment 74 — Neutralization

MATERIALS. — Sodium hydroxide (solid), blue litmus paper.

Dissolve a small piece of sodium hydroxide in an evaporating dish one-third full of water. Add a little dilute hydrochloric acid, and stir thoroughly; continue to add the acid, until a drop of the well-mixed solution taken from the dish by a clean glass rod just reddens blue litmus paper. If the dish becomes too full, pour out some of the solution.

Evaporate the solution to dryness by heating the dish on a gauze-covered ring. Heat until the yellow color (due to the slight excess of hydrochloric acid added) disappears, then moisten the whole residue carefully with a little warm water, and heat again to evaporate the last traces of acid; add and evaporate two portions of water.

Test small portions of the residue. (1) Apply the litmus test. Has the residue acid, basic, or neutral properties? (2) Taste a little. Is it an acid, base, or salt? (3) Dissolve some in water and

test the solution for a chloride. State the result. (4) Test for sodium by heating a little on a test wire in the flame. State the result. What is the residue? Write the equation for the reaction.

Experiment 75 — Neutralization by Titration

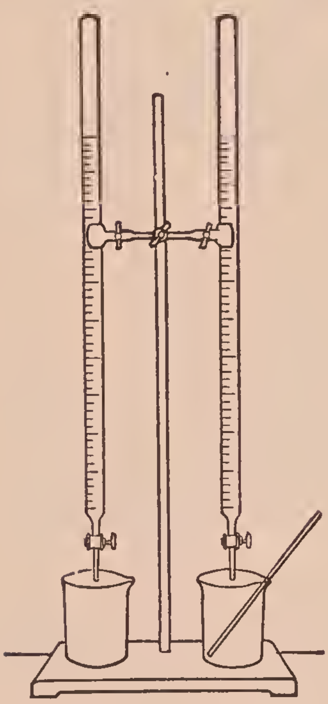


FIG. 46. — Burettes for accurate experiments in neutralization

OBJECT. — To find the number of grams of the compound HCl in 1 cc. of a solution of hydrochloric acid (*i.e.* HCl dissolved in water) by neutralizing the acid with a solution of sodium hydroxide of known concentration.

MATERIALS. — Phenol-phthalein solution, and solutions of hydrochloric acid and sodium hydroxide (the latter of known concentration and obtained from the Teacher).

APPARATUS. — Burettes, beakers, and glass rod as in Fig. 46, waste beaker.

Copy the form of RECORD given below in the notebook and enter each volume as soon as the reading is made.

Fill each burette (or start with each full) — one with the acid solution and one with the base solution (Fig. 46). Be sure the tip of the burette is free from air bubbles. Place the waste beaker under each burette in turn and allow the solution to run out slowly until the bottom of the meniscus rests on the 0 line when the eye is on a level with the same line. (See Fig. 47.) Set the waste beaker aside.

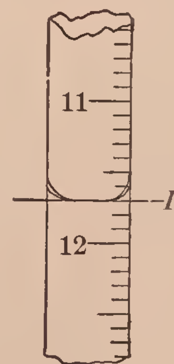


FIG. 47. — Meniscus (correct reading along line *I*)

Put a clean beaker under the base burette and let exactly 15 cc. run into the beaker; enter in I in the RECORD. Remove the beaker, add 2 or 3 drops of phenol-phthalein solution, put the beaker under the acid burette, and let the acid solution run in slowly, stirring constantly with the clean rod until the red color just disappears and the solution becomes colorless. Read the exact volume of acid solution added and enter in I.

RECORD

I.	NaOH sol. 0 – 15 = 15		
	HCl sol. 0 – =	1 cc. NaOH sol. =	cc. HCl sol.
II.	NaOH sol. 15 – 30 = 15		
	HCl sol. – =	1 cc. NaOH sol. =	cc. HCl sol.
III.	NaOH sol. 30 – 45 = 15		
	HCl sol. – =	1 cc. NaOH sol. =	cc. HCl sol.
	∴ 1 cc. NaOH sol. =	cc. HCl sol. (average)	

Pour the solution out of this beaker, wash the beaker, and proceed, as before, with a second 15 cc. of NaOH solution. Enter in II.

Wash the beaker and proceed with a third 15 cc. of NaOH solution. Enter in III.

Calculation. — Our problem is to calculate the number of grams of HCl in 1 cc. of the solution of hydrochloric acid used in this experiment.

(*a*) First write the equation for the reaction, thus: —

$$\underset{36.5}{HCl} + \underset{40}{NaOH} = \underset{58.5}{NaCl} + \underset{18}{H_2O}$$

This equation means that 36.5 gm. of HCl are needed to neutralize 40 gm. of NaOH.

(*b*) Next find (from I, II, III, above) the average number of cubic centimeters of hydrochloric acid solution which would be neutralized by 1 cc. of sodium hydroxide solution. For example, suppose 1.5 cc. HCl sol. = 1 cc. NaOH sol. (Your result, of course, may be different from this value.)

(*c*) Learn from the Teacher the concentration of the sodium hydroxide solution. For example, suppose 1 cc. of sodium hydroxide solution contains 0.00641 gm. of NaOH.

(*d*) Now from the equation in (*a*) we see that 40 gm. of NaOH require 36.5 gm. of HCl. Then the number of grams of HCl required by 0.00641 gm. of NaOH would be found by the proportion

$$40 : 36.5 :: 0.00641 : x \qquad x = 0.00585$$

(Your result depends on the concentration of your NaOH solution.) But 0.00585 gm. of HCl would be dissolved in 1.5 cc. of hydrochloric acid (according to our supposition in (*b*)). Therefore, to find the number of grams of HCl that would be dissolved in 1 cc. of the acid solution, we divide 0.00585 by 1.5, *i.e.* $0.00585 \div 1.5 = 0.0039$. *Ans.* 0.0039 gm. of HCl in 1 cc.

Experiment 76 — Preparation of a Salt by Various Methods

Materials. — Calcium, calcium oxide, carbonate, and chloride, silver nitrate solution.

a. **Acid and a metal.** — Put a small piece of calcium in an evaporating dish, add a little dilute hydrochloric acid, stand the dish on a gauze-covered ring, and heat gently in the hood until the calcium disappears, adding more acid if necessary. Then evaporate the solution to dryness; heat gently toward the end to prevent spattering. Moisten the residue with water, and evaporate again to dryness. Heat the residue until no more fumes of hydrochloric acid are evolved. Let the dish cool, and loosen the solid with a glass rod.

Test small portions of the residue for (1) calcium (flame test), and (2) a chloride. State the result.

b. **Acid and an oxide.** — Proceed as in **a**, using hydrochloric acid and a small piece of calcium oxide. Test the final residue as in **a**. State the result.

c. **Acid and a salt.** — Proceed as in **a**, using hydrochloric acid and a small piece of calcium carbonate. Test the final residue (as in **a**). State the result.

d. **Two salts.** — Add silver nitrate solution to calcium chloride solution, and describe the result.

Required Exercises. — 1. What is the name and formula of the residue in each part of this experiment? Write the equation for each reaction.

2. Suggest a simple experiment to verify the answer in 1.

3. Suggest experiments to prove that the residue is neither an acid nor a base.

e. **Acid and base.** — Recall an experiment in which a salt was formed by the interaction of an acid and a base. Name all the compounds involved in the reaction. Write the equation.

AMMONIA — AMMONIUM COMPOUNDS

(Practical Chemistry, pp. 148–157, §§ 168–181)

Experiment 77 — Ammonia (Gas) and Ammonium Hydroxide

Materials. — Lime (calcium oxide), ammonium chloride, concentrated hydrochloric acid.

Apparatus. — As in Fig. 48. The test tube *A* is provided with a one-hole

rubber stopper to which is fitted a glass tube *B* which reaches well up into the bottle *C*, 3 bottles, pneumatic trough filled as usual. Optional forms of apparatus (as in Fig. 49) may be used.

Caution. — Do not inhale ammonia (gas). Perform this experiment in the hood.

Weigh 10 gm. of lime and 10 gm. of ammonium chloride separately, and mix them thoroughly on a piece of paper. Slip the mixture into *A*, and add a little water, thereby transforming the calcium oxide into calcium hydroxide. Mix well. Quickly insert the stopper with its tube, and clamp *A* as in Fig. 48. Stand the bottle *C* over the tube *B*.

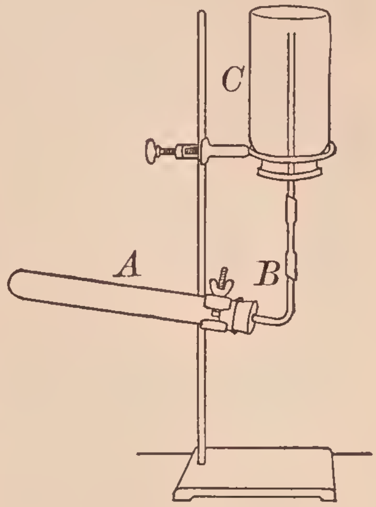


FIG. 48. — Apparatus for preparing ammonia

Heat *A* gently with a low flame. (Begin to heat the test tube near the closed end and slowly work forward to the delivery tube.) Ammonia (gas) will pass up into the bottle, which should be removed, when full, and covered tightly with a glass plate or filter paper. A piece of moist red litmus paper held near the mouth will show (by change in color) when the bottle is full. *Do not smell at the mouth of the bottle.* Collect two bottles of the gas.

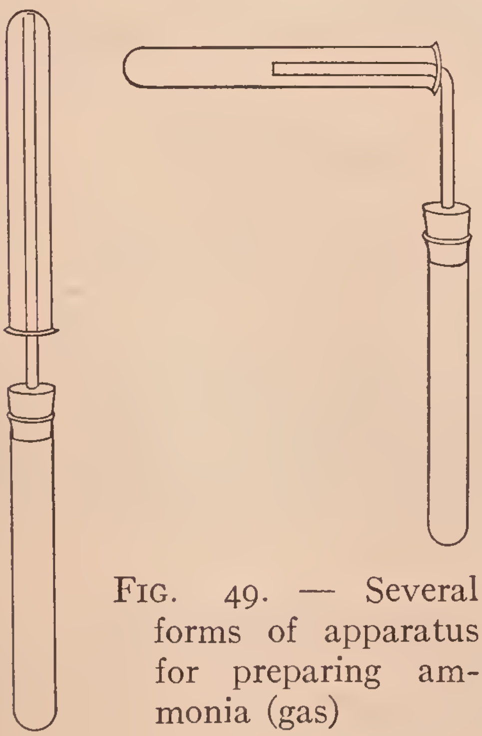


FIG. 49. — Several forms of apparatus for preparing ammonia (gas)

a. Test the gas in one bottle or test tube with a blazing joss stick. Observe the result. Compare with the behavior of oxygen, carbon dioxide, hydrogen, and hydrogen chloride under similar circumstances.

b. Invert the same bottle in the pneumatic trough, and shake it vigorously, taking care to keep the mouth under water. Observe the change inside the bottle. What property of the gas is revealed? Is it a marked property? Test the contents of the bottle with litmus paper (both colors), and state the result.

c. Pour a few drops of concentrated hydrochloric acid into an empty, warm, dry bottle. Rotate the bottle until the inside is well moistened with the acid. Cover it with a glass plate, invert it, and

stand it upon a covered bottle of ammonia (gas). Remove both plates at once, and hold the bottles together by grasping them firmly about their necks. Observe the result. Describe the result, giving the evidence of the chemical action. What is the white substance?

d. State other properties of ammonia (gas) you have observed in this experiment, *e.g.* color, odor, density, and behavior with moist litmus paper.

Experiment 78 — Ammonia (Gas) from Various Substances

MATERIALS. — Gelatin, soda-lime, litmus paper, concentrated hydrochloric acid, substances enumerated in **b**, ammonium sulphate, ammonium nitrate, sodium hydroxide solution, calcium cyanamide (for **f**), ammoniacal liquor (for **g**).

a. Mix a little gelatin and soda-lime on a piece of paper, slip the mixture into a test tube, attach a test tube holder, heat, and test the escaping gas with moist red litmus paper, or by a glass rod moistened with concentrated hydrochloric acid. State the result.

b. Repeat **a**, using soda-lime with hair, feather, leather scraps, or pieces of horn. Observe and state the results.

c. Dissolve a little ammonium chloride in water, add a little sodium hydroxide solution, warm gently, and test (cautiously) the liberated gas by its odor. What is the gas?

d. Repeat **c**, using ammonium sulphate and sodium hydroxide solution. State the result.

e. Proceed as in **d**, using ammonium nitrate. Test (by the odor) the gaseous product, and state the result.

f. Put about 5 gm. of calcium cyanamide in a test tube, add 10 cc. of water, shake, boil, and test for ammonia. State the result.

g. Optional. Add powdered calcium oxide (lime) to a test tube half full of ammoniacal liquor, warm gently, and test the escaping gas for ammonia. State the result.

Experiment 79 — Properties of Ammonium Salts

MATERIALS. — Ammonium chloride, sodium hydroxide, sand, ammonium nitrate, ammonium carbonate.

a. Examine ammonium chloride and state its characteristic properties.

b. Add a few grams of ammonium chloride to a test tube half full of water, shake well, and observe the result. Does ammonium chloride dissolve easily in water? Add a little more of the salt, shake,

and note how the dissolving affects the temperature of the solvent. Save the solution for **c**.

c. Add a small piece of sodium hydroxide to the solution from **b**, warm gently, and very cautiously observe the odor of the gaseous product. What is the gas? Explain its formation.

d. Put a little crude ammonium chloride (or a mixture of ammonium chloride and sand) in a clean, dry test tube, heat the closed end gently, and observe the result. What is the white deposit? Heat intensely. Is there a residue? If so, compare it with the white deposit. What general name is given to this process? To the product?

e. Add a little ammonium nitrate to sodium hydroxide solution in a test tube, warm gently, and cautiously note the gaseous product. What is it? Moisten a glass rod with concentrated nitric acid and hold it at the mouth of the test tube (after warming again, if necessary). Describe the result. What is the product?

f. Smell of a lump of ammonium carbonate. To what substance is the odor due? Moisten with water and smell again. What is the product?

Answer: 1. What is the test for ammonium compounds?

2. What is the equation for the reaction in **c**? For the two reactions in **e**?

Experiment 80 — Testing Salts (Review)

Materials. — Chlorides, sulphates, carbonates, and nitrates of sodium, potassium, calcium, barium, and ammonium; nitrates of silver, lead, and mercury; dilute hydrochloric acid.

Obtain several "unknowns" from the substances enumerated above and test a separate portion of each for (*a*) the metal part, *i.e.* sodium, potassium, calcium, barium, silver, lead, ammonium, and (*b*) the non-metal part, *i.e.* a chloride, a sulphate, and a carbonate. State each result. Give the name and formula of each salt.

NITRIC ACID — NITRATES — NITROGEN OXIDES

(Practical Chemistry, pp. 159–170, §§ 182–197)

Experiment 81 — Nitric Acid

Materials. — Sodium nitrate, concentrated sulphuric acid, quill toothpick, copper wire, zinc, magnesium ribbon.

Apparatus. — Glass stoppered retort, etc., as in Fig. 50.

Caution. — Concentrated nitric acid and sulphuric acid are very corrosive. Do not spill them on the flesh or the clothing.

NOTE. — I may be omitted and **II** done with concentrated nitric acid from the laboratory bottle.

I. Preparation. — Weigh 20 gm. of sodium nitrate and slip it into the retort through the tubulure. Fill the bottle nearly full of water. Put a large empty test tube into the bottle, insert the neck of the retort into the test tube, and arrange the apparatus as shown in Fig. 50. Stand a funnel in the tubulure of the retort so that the end is well inside the bulb, and pour 20 cc. of concentrated sulphuric acid through the funnel. Remove the funnel and insert the stopper of the retort tightly.

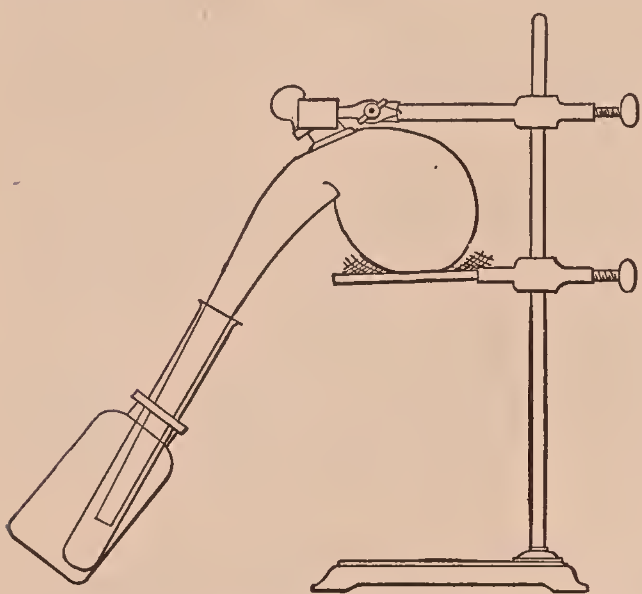


FIG. 50. — Apparatus for preparing nitric acid in the laboratory

Heat the retort gently as long as any nitric acid runs down the neck into the test tube. Then unclamp the retort and remove the test tube carefully, taking care not to get any nitric acid on the hands.

NOTE. — Allow the contents of the retort to cool, add a little water, boil until the solid in the bulb is reduced to a small bulk or dissolved, and pour it into a waste jar in the hood.

II. Properties. — **a.** Observe the color of the concentrated nitric acid prepared in **I.** Compare it with the concentrated nitric acid in several bottles in the laboratory and with the typical specimen of concentrated nitric acid placed upon the side shelf by the Teacher. State the result.

b. Hold a piece of wet filter paper at the mouth of the test tube of concentrated nitric acid. Observe and state the result.

c. Repeat **b**, using a piece of filter paper moistened with ammonium hydroxide. What is the name of the product?

d. Pour 5 cc. of concentrated nitric acid *very carefully* into a test tube, drop in a piece of a quill toothpick, and observe any change in the color of the quill. Heat very gently, and observe the effect on the quill. State the final result.

e. Put about 1 gm. of sulphur in a test tube, add a little water and then very carefully 5 cc. of concentrated nitric acid. Attach the test tube holder, and boil cautiously — in the hood — for a few minutes. Add 10 to 15 cc. of water, filter the solution, if it is not clear, and test the filtrate for a sulphate by adding barium chloride solution. State the result. Explain it.

f. Stand three test tubes in the test tube rack, put a piece of zinc into one, copper into another, and magnesium ribbon (rolled into a ball) into the third. Add a little concentrated nitric acid to each test tube. Observe the result. Test the gaseous product for hydrogen, and state the result.

Required Exercises. — 1. What property of nitric acid was shown by **b**? By **d**? By **e**?

2. How does the action in **b** and **c** compare with that of hydrochloric acid under similar circumstances?

3. Apply Exercise 2 to **f**. (If in doubt, try the experiment.)

Experiment 82 — Properties of Nitrates

Materials. — Copper nitrate, lead nitrate, potassium nitrate, charcoal.

a. Put a little copper nitrate in a test tube, attach the holder, heat gently, and observe the result, especially the color of the gaseous product and of the final solid product. Test the gaseous product for oxygen. State the result.

Devise an experiment to determine the qualitative composition of the solid product; consult the Teacher before proceeding.

b. Pulverize a little lead nitrate and proceed with it as in **a**. State the results.

c. Proceed as in Exp. 9 **a**.

Experiment 83 — Interaction of Nitric Acid and Metals

Materials. — Zinc, copper, tin, iron, concentrated nitric acid.

Stand four test tubes in the test tube rack. Slip into one a few pieces of zinc, into another a small piece of tin, into the third a small quantity of copper borings, and into the fourth a small quantity of clean iron filings. Add to each test tube in succession enough concentrated nitric acid to cover the metal. Warm slightly, if there is no action. Observe and describe the changes, particularly (1) the vigor of the action, (2) the properties of the solid products, especially color and solubility, and (3) the properties of the gaseous prod-

ucts. Name the solid product and the gaseous product of the reaction in each case.

Experiment 84 — Test for Nitric Acid and Nitrates

MATERIALS. — Ferrous sulphate, sodium nitrate.

a. To 10 cc. of water add 1 or 2 cc. of concentrated nitric acid and shake. Prepare a ferrous sulphate solution by dissolving a clean crystal in 10 cc. of cold water.

Pour this solution into the nitric acid. Mix well. Incline the test tube and pour about 5 cc. of concentrated sulphuric acid down the inside of the tube. The sulphuric acid will sink through the other liquid. At the surface where the two solutions meet, a brown or black layer will appear (Fig. 51).

b. Proceed as in **a**, using a concentrated solution of sodium nitrate instead of nitric acid. Record the result.

Experiment 85 — Nitric Oxide and Nitrogen Dioxide

MATERIALS. — Copper (borings or fine pieces of sheet metal), concentrated nitric acid, piece of copper wire (15 cm. or 6 in. long).

Put 10 gm. of copper in the bottle, and arrange the apparatus to collect the gas over water (Fig. 52). Fill three bottles with water, and invert one of them in the trough. Have the others ready.

FIG. 51. — Test for nitric acid and nitrates

Dilute 25 cc. of concentrated nitric acid with an equal volume of water, and introduce just enough of this dilute acid through the dropping tube to cause gentle chemical action. If the action is too vigorous, add water through the dropping tube; if too weak, add a little of the dilute nitric acid.

Collect three bottles of the gas, which is nitric oxide, and cover them with glass plates.

a. Observe the general properties of nitric oxide while covered.

b. Uncover a bottle. Observe the result. Is the brown gas, which is formed, identical in color with the one observed in the generator at the beginning of the experiment? What is the brown gas?

c. Uncover a bottle, let the brown gas form, then pour in about 25 cc. of water, cover with the hand and shake vigorously, still keeping the bottle covered. Does the brown gas disappear?

d. With the third bottle, determine whether the gases will burn or support combustion. A convenient flame is a burning match fastened to a copper wire. Uncover a bottle and plunge the lighted match quickly to the bottom of the bottle and immediately replace the glass plate. Observe the result. Remove the glass plate and observe the result.

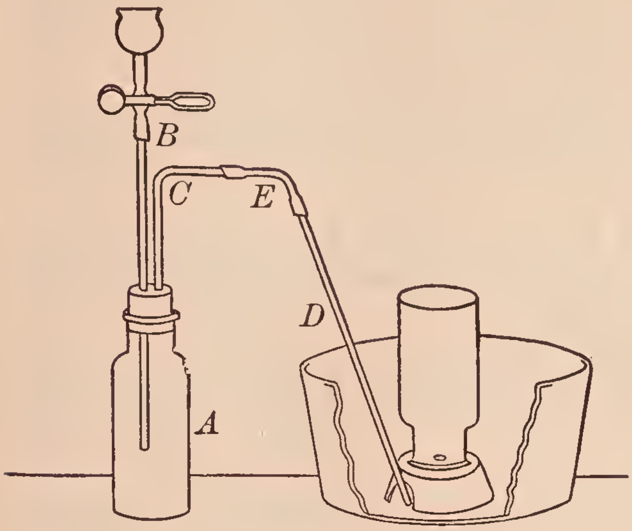


FIG. 52. — Apparatus for preparing nitric oxide

REQUIRED EXERCISES. — 1. Summarize the properties of nitric oxide. Of nitrogen dioxide.

2. What is the general chemical relation of the two gases to each other? To the air?

3. Why cannot nitrogen dioxide be collected over water?

Experiment 86 — Preparation and Properties of Nitrous Oxide

MATERIALS. — Ammonium nitrate, wad of iron thread, copper wire, sulphur, joss stick.

Put 10 gm. of ammonium nitrate in the flask *A*. Construct and arrange the apparatus as shown in Fig. 53. The large test tube *B* remains empty. The end of *H* rests on the bottom of the pneumatic trough, which is filled as usual. Be sure the apparatus does not leak.

I. Preparation. — Heat the flask gently with a low flame, and readjust the apparatus if it leaks. The ammonium nitrate melts at first and soon appears to boil, owing to the decomposition of the salt and escape of nitrous oxide. Regulate the heat so

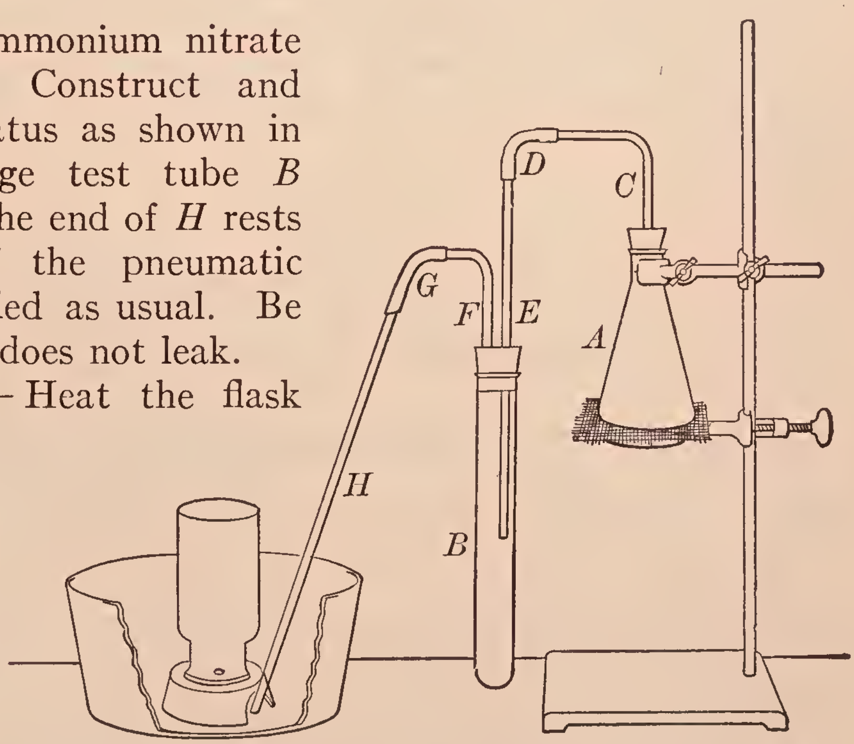


FIG. 53. — Apparatus for preparing nitrous oxide

that the evolution of the nitrous oxide is slow. Notice the liquid which collects in *B*. Collect three bottles of nitrous oxide, covering each with a piece of filter paper as soon as removed from the trough. When the last bottle has been collected and covered, remove the end of the delivery tube from the trough.

II. Properties. — a. Allow a bottle to remain uncovered for a few seconds. How does nitrous oxide differ from nitric oxide? Nitrogen dioxide?

b. Thrust a glowing joss stick into the same bottle of gas. Observe the result. Is the gas combustible? Does it support combustion?

c. Put a piece of sulphur in a deflagrating spoon, light it, and lower the burning sulphur *at once* into another bottle of gas. Observe the result.

d. Twist one end of the copper wire around a wad of iron thread. Heat the edge of the wad an instant in the flame and then lower it *quickly* into a bottle of the gas. Observe the result. Recall a similar experiment with oxygen. Compare the two results.

Required Exercises. — 1. Summarize the essential properties of nitrous oxide.

2. What is the other product (seen in *B*) of the chemical change in this experiment?

3. How could you distinguish ammonium nitrate from other nitrates?

4. How could you distinguish nitrous oxide from (*a*) the other oxides of nitrogen, (*b*) air, (*c*) oxygen, (*d*) hydrogen, (*e*) nitrogen, (*f*) carbon dioxide?

MOLECULAR WEIGHTS

(Practical Chemistry, pp. 171–180, §§ 198–208)

Experiment 87 — Weight of 22.4 Liters of Carbon Dioxide

Object. — To find the volume of carbon dioxide liberated from a weighed amount of calcium carbonate and to calculate the weight of 22.4 l. of this gas.

Materials. — Crystallized calcium carbonate, concentrated hydrochloric acid.

Apparatus. — As in Fig. 54, glass plug for stopper of *A*. *A* is a 125 cc. Erlenmeyer flask in which the carbon dioxide is generated. The large bottles *C* and *E* are dry and empty. *G* is a 750 cc. bottle filled with water and inverted in the pneumatic trough as usual.

Copy the form of RECORD as given below in your notebook and enter each item as soon as the weighing or measuring is made.

Construct and arrange the apparatus as in Fig. 54. Put 20 cc. of concentrated hydrochloric acid and 5 cc. of water in *A*, mix well, add a small piece of *unweighed* calcium carbonate, insert the stopper loosely, and let the flask remain undisturbed until the calcium carbonate disappears; the object of this is to fill *A* with carbon dioxide before weighing (since it is full of the gas at the end).

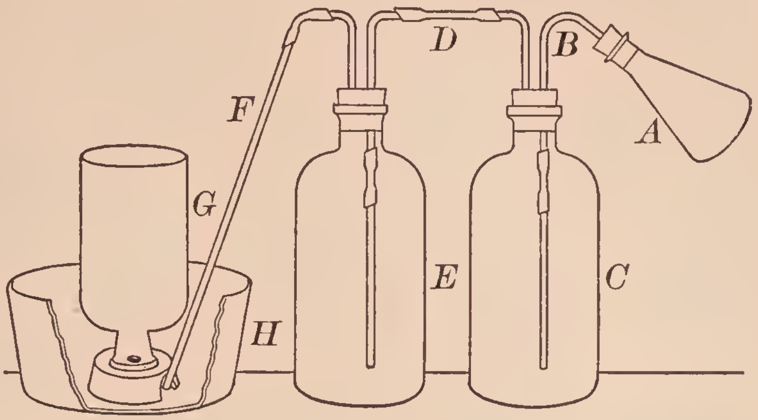


FIG. 54. — Apparatus for finding the weight of 22.4 liters of carbon dioxide

Meanwhile weigh accurately on the balance 2.5 to 3 gm. of calcium carbonate. (See Introduction, § 8, for instructions about weighing.) Enter the weight as (*b*) below. When the evolution of gas stops in *A* insert a glass plug in the hole of the stopper and weigh the whole on the balance. Record the weight as (*a*) below. Remove and preserve the plug.

RECORD

	Thermometer (*t*) . . . . ° Barometer (*P′*) . .	mm.
(*a*)	Weight of flask, stopper, plug, and acid	gm.
(*b*)	Weight of calcium carbonate	gm.
(*c*)	Weight of flask, stopper, plug, etc. — before action . .	gm.
(*d*)	Weight of flask, stopper, plug, etc. — after action . .	gm.
	(*e*) Weight of carbon dioxide ((*c*) − (*d*)).	gm.
(*f*)	Volume of carbon dioxide (observed)	cc.
	(*g*) Volume of carbon dioxide (corrected)	cc.
(*h*)	Weight of a liter of carbon dioxide	gm.
(*i*)	Weight of 22.4 liters of carbon dioxide	gm.

Carefully push *A* with its stopper upon the tube *B*, remove the flask, hold it near the stopper, slip in the weighed calcium carbonate and *instantly* push the flask firmly upon the stopper. The carbon dioxide soon forces air into *G*. If no bubbles arise in *G*, examine the apparatus for a leak and quickly readjust, if necessary.

Let the operation continue until the gas ceases to rise in *G*. Then

carefully joggle *G* to dislodge any bubbles which may be underneath the support. Slide the bottle from the support down upon the bottom of the trough. Add water to the trough, if the level is below the level inside the bottle; if unnecessary, raise the bottle until the water is at the same level inside and outside. Slip two pieces of filter paper beneath the bottle, cover the mouth firmly, invert and remove, and stand it right side up on the table. Stand a thermometer in the bottle, and read and record the temperature (t) after a few moments. Also read and record the barometer (P').

Fill a large graduate (preferably 1000 cc.) with water to the mark and pour water carefully from the graduate into *G* until full. Read the exact volume of the water added to *G* and record as (f); this is the volume of carbon dioxide liberated. Correct it for temperature, pressure, and aqueous tension by the method given in Exp. 24. Enter the corrected volume as (g).

Weigh *A* with its contents, stopper, and plug, and enter the weight as (d).

From the weight of carbon dioxide ((c) − (d)) and the corrected volume (g) calculate the weight of a liter, and record as (h) above. Multiply this weight (h) by 22.4 and record as (i).

Answer: 1. What is the exact weight of a liter of carbon dioxide? What weight did you obtain? What is the class average?

2. What is the weight of 22.4 liters of carbon dioxide calculated from the class average of the weight of one liter?

3. What is the weight of 22.4 liters of oxygen calculated from the class average of Exp. 24?

EQUIVALENT WEIGHTS

(Practical Chemistry, pp. 182–190, §§ 209–216)

Experiment 88 — Equivalent of Zinc (to Hydrogen)

Object. — To find the number of grams of zinc chemically equivalent to one gram of hydrogen.

Apparatus. — As in Fig. 55, pneumatic trough (not zinc), thermometer, barometer.

Copy the form of Record in the notebook and enter each weight or volume as soon as the weighing or measuring is made.

Construct and arrange the apparatus (Fig. 55) to collect a gas over water, and have it inspected by the Teacher.

Weigh from 0.45 to 0.5 gm. of zinc on the balance. Take a single piece and weigh it exactly. Enter in the RECORD as *Zn*.

RECORD

Weight of zinc taken (*Zn*)	gm.
Observed volume of hydrogen (*V′*)	cc.
Temperature (*t*)	°
Pressure (*P′*)	mm.
Vapor pressure (*a*)	mm.
Corrected volume of hydrogen (*V*)	cc.
Weight of corrected volume of hydrogen (*W*)	gm.
Equivalent of zinc (*E*)	gm.

Put the weighed zinc into the bottle *A*. Fill the bottle with water and insert the stopper with all its tubes. Next fill the remainder of the apparatus with water by first filling the cup with water and then admitting it repeatedly until all air is forced out of the bottle and tubes; take care never to let the water in *B* fall below the lower opening of the cup. Note that the inner end of the tube *C* does not extend below the stopper.

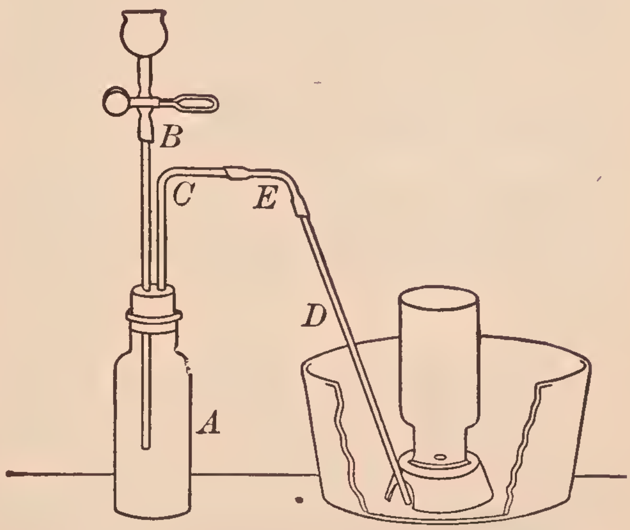


FIG. 55. — Apparatus for finding the equivalent of zinc

Fill a 250 cc. bottle with water and invert it upon the support in the trough (a sheet zinc trough must not be used). Put the end of the delivery tube under the support and ask for a final inspection. Heat about 50 cc. of dilute sulphuric acid in a test tube. Fill the cup and introduce the hot acid in separate portions slowly into the bottle *A*, taking the same care as before. The liberated hydrogen will slowly accumulate in the receiving bottle.

Let the action continue until the zinc is used up. Then force over into the collecting bottle all gas in the apparatus by admitting water carefully as before. Lay a piece of dry filter paper upon the bottom of the bottle, grasp the bottle firmly, carefully joggle it to dislodge any gas bubbles which may be underneath the support,

slide the bottle from the support, and lower it into the water until the water is at the same level inside and outside the bottle; then slip two pieces of filter paper beneath the bottle, cover the mouth firmly, lift the bottle from the trough and stand it, right side up, upon the table. Stand a thermometer in the trough.

Fill a 250 cc. graduate exactly to the mark with water, remove the paper cover from the bottle, and very carefully fill the bottle with water from the graduate; read and enter (as V') the exact volume of water added; this is the volume of hydrogen liberated. Read the thermometer while the bulb is in the water, and enter as t. Read the barometer, and enter as P'. Find the vapor pressure corresponding to the observed temperature (see Appendix, § 4), and enter as a.

Correct the observed volume (V') of hydrogen for temperature, pressure, and vapor pressure, and enter as V. Since 1000 cc. of dry hydrogen weigh 0.09 gm., the weight (W) of the corrected volume (V) is found by $1000 : V :: 0.09 : W$. And the weight of zinc equivalent (E) to one gram of hydrogen is found by $W : Zn :: 1 : E$. Enter the equivalent of zinc as E. Submit the result to the Teacher before taking the apparatus apart.

Required Exercises. — 1. Calculate the atomic weight of zinc by multiplying the equivalent weight (found in this experiment) by 2.

2. Compare this calculated atomic weight with the approximate atomic weight.

3. Calculate, as in Exercise 1, from the class average.

4. Compare the number obtained in 3, as in Exercise 2.

Experiment 89 — Equivalent of Magnesium (to Hydrogen)

Object. — To find the number of grams of magnesium equivalent to 1 gm. of hydrogen.

Materials. — Magnesium ribbon, concentrated hydrochloric acid.

Apparatus. — A 100 cc. tube, pneumatic trough (not zinc), thermometer, barometer, tall jar (*e.g.* 1000 cc. graduate).

Prepare a form of Record like that in Exp. 88 and enter the items, when available, in the proper place.

Weigh accurately from 0.06 to 0.07 gm. of magnesium ribbon, preferably in a single piece. Enter the exact weight as Mg. Have the trough (not zinc) half full of water. Pour 10 cc. of concentrated hydrochloric acid into the 100 cc. tube and fill the tube completely with cold water. Put the magnesium into the water in the tube, cover the end of the tube with the thumb or finger, invert and stand

it in the trough, but keep the end loosely closed to prevent the magnesium from slipping out. As the acid sinks through the water and reaches the magnesium, action begins vigorously. Hydrogen rises rapidly in the tube and usually carries the magnesium with it. Watch the operation, and shake the tube to prevent the magnesium from sticking to the inside. If a piece of magnesium should stick to the inside of the tube, close the end of the tube tightly, lift it from the water, incline it enough to let the liquid run down and loosen the magnesium, and then quickly put the end of the tube beneath the water.

When all the magnesium has disappeared, close the end of the tube, remove the tube to a tall jar of water, and let it stand five or more minutes; then, by a clamp (without touching the tube with the hands) adjust the height so that the water levels are the same inside and outside of the tube. Read the volume of hydrogen, and enter as the observed volume (V'). Read the barometer and the thermometer (keeping the bulb in the water).

Correct the observed volume (V') for temperature, pressure, and vapor pressure, and enter as the corrected volume (V). Find the weight (W) of this volume (V) of hydrogen. Calculate the equivalent of magnesium to hydrogen, as in Exp. 88. Enter the equivalent of magnesium as E.

Required Exercises. — As in Exp. 88.

Experiment 90 — Equivalent of Aluminium (to Hydrogen)

Proceed as in Exp. 88. Use about 0.17 gm. of aluminium (taking care to weigh exactly the amount used). Use hot concentrated hydrochloric acid instead of dilute sulphuric acid. Record and calculate as in Exp. 88.

Required Exercises. — As in Exp. 88.
Note. — The multiplier in Exercise 1 is 3.

Experiment 91 — Equivalent of Calcium (to Hydrogen)

Proceed as in Exp. 89. Use about 0.11 gm. of calcium. Record and calculate as in Exp. 89.

Required Exercises. — As in Exp. 88.

Experiment 92 — Equivalent of Zinc (to Oxygen)

Object. — To prepare zinc oxide from a weighed amount of zinc and to find the relative weights of zinc and oxygen.

APPARATUS. — Evaporating dish fitted with a glass cover, pointed glass tube, water bath.

Copy the form of RECORD given below in your notebook, and enter each weight as soon as the weighing is made.

Clean and dry an evaporating dish. Weigh it on the balance accurately. Put about 1 gm. of zinc in it, weigh again, and enter the exact weight.

RECORD

Weight of dish and zinc		gm.
Weight of dish	———	gm.
Weight of zinc		gm.
Weight of dish and zinc oxide I gm., II gm., III		gm.
Weight of dish	———	gm.
Weight of zinc oxide		gm.
Weight of zinc	———	gm.
Weight of oxygen		gm.

Stand it on a crucible block, add 5 cc. of water, cover the dish with a glass cover (preferably a watch glass — convex side down), and add concentrated nitric acid, a little at a time, by letting the acid run into the dish from a pointed tube held in the opening between the cover and the lip of the dish. Add acid at intervals until the zinc disappears. Then remove the glass cover, hold it edgewise over the dish, and rinse off the drops into the dish by pouring a little water upon the upper part of the cover.

Stand the dish on a water bath and let the liquid evaporate (without the glass cover). When only a small amount of sirupy liquid is left, transfer the dish from the water bath to a crucible block, carry it to the hood, stand it on a gauze-covered ring, and heat *very gently* with a low flame. Hold the burner in the hand, and regulate the heat to prevent spattering. Continue to heat as the mass thickens and gives off red fumes; as soon as the mass becomes perfectly dry, heat strongly for about five minutes. Cool, weigh, and enter the weight as I. Heat again intensely for five minutes, cool, weigh, and enter as II. If the weights are not the same, submit the result to the Teacher. A third heating and weighing may be necessary.

The zinc was changed to zinc nitrate by the acid, and the nitrate to zinc oxide by heating. The equivalent weight of oxygen is 8. Calculate the equivalent weight of zinc to oxygen. Submit the result to the Teacher before removing the zinc oxide from the dish.

REQUIRED EXERCISES. — As in Exp. 88.

Experiment 93 — Equivalent of Zinc (to Chlorine)

OBJECT. — To prepare zinc chloride from a weighed amount of zinc and to find the relative weights of zinc and chlorine.

APPARATUS. — As in Exp. 92, desiccator (optional).

Prepare a form of record like that in Exp. 92, substituting chloride for oxide and chlorine for oxygen.

Weigh a clean, dry porcelain dish accurately. Add from 1.5 to 2 gm. of zinc, and weigh exactly. Record each weight. Introduce concentrated hydrochloric acid (instead of nitric acid) into the covered dish as in Exp. 92. Evaporate on the water bath until nothing escapes from the dish. Then transfer the dish to a gauze-covered ring and heat gently with a low flame to remove the last portion of water. Zinc chloride is volatile at a low temperature. Hence, it must be heated gently. Remove the flame as soon as fumes begin to appear. Pass the flame over the surface occasionally to assist the removal of the last traces of water.

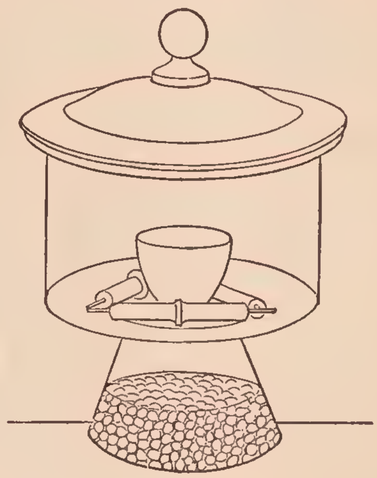


FIG. 56. — A desiccator for keeping zinc chloride dry

When it is judged that all the water has been removed, put the dish in a desiccator (Fig. 56), let it cool, and then weigh. Zinc chloride is deliquescent. Hence the dish and contents must be weighed quickly. It is hardly possible to get weights which agree, but the variation should not be much.

The equivalent of chlorine is 35.5. Calculate the equivalent of zinc to chlorine. Submit the result to the Teacher before removing the contents from the dish.

REQUIRED EXERCISES. — As in Exp. 88.

IONS AND IONIZATION

(Practical Chemistry, pp. 201–216, §§ 230–247)

Experiment 94 — Electrolytes and Non-Electrolytes

(Demonstration Experiment)

OBJECT. — To find out whether a substance forms a conducting or a non-conducting solution.

MATERIALS. — Hydrochloric acid, sodium hydroxide, calcium chloride, sugar, alcohol, glycerin.

APPARATUS. — As in Fig. 57. *A* is a beaker for the solution, *B* and *C* are electrodes (of aluminium or platinum) which are supported on the top of the beaker by a strip of wood. *D* is an electric light bulb which is connected with the wire from the electrode *B* and with one end of the wire *E*. The wire from the electrode *C* and the other end of the wire *E* are connected with the street current (reduced) or with a storage battery.

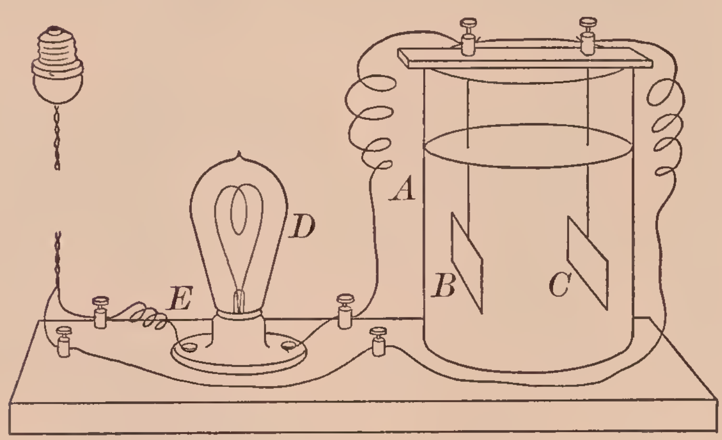


FIG. 57. — Apparatus for showing what solutions conduct electricity

a. Construct and arrange the apparatus as in Fig. 57. Fill the beaker two-thirds full of dilute hydrochloric acid, see that all connections are tight, and turn on the current. Does the bulb glow? Why?

b. Proceed as in **a**, using successively solutions of sodium hydroxide, calcium chloride, sugar, alcohol, and glycerin. Clean the beaker each time. Observe and state each result.

Answer: 1. What substances form solutions which conduct electricity?
2. What substances form non-conducting solutions?
3. What is the name of the classes of substances in 1? In 2?

Experiment 95 — Chemical Behavior of Solutions of Salts

MATERIALS. — For **a**, solutions of silver nitrate, silver sulphate, and chlorides of ammonium, barium, calcium, magnesium, sodium, and potassium; potassium chlorate, potassium perchlorate. For **c**, solutions of barium chloride, barium nitrate, sulphates of copper, sodium, aluminium, magnesium, and zinc.

a. Test separately a dilute solution of the substances enumerated under **a** by adding a few drops of silver nitrate solution. State the result in each case.

b. Add a few drops of silver sulphate solution to several of the solutions used in **a**. State the result.

c. Test separately a dilute solution of substances enumerated under **c**, by adding to each a few drops of barium chloride solution. State the result in each case.

d. Proceed as in **c**, using a few drops of barium nitrate solution in place of barium chloride.

Required Exercises. — 1. What ion is common to solutions of chlorides? Of sulphates?

2. Explain the general result in **a** in terms of the theory of ionization. Also the results in **b**.

3. What ion is in solutions of all barium salts? All silver salts?

4. What ion other than hydrogen is in a solution of sulphuric acid? What ion other than potassium ion is in a solution of potassium chlorate? Of potassium perchlorate?

5. What ion is in solutions of all acids? Of all bases? Of all sodium salts?

6. Make a list of the salts used in the whole experiment and their corresponding ions, indicating the ions by name and formula.

Experiment 96 — Electrolysis of Copper Sulphate Solution — Short Method

(Demonstration Experiment)

Material. — Dilute copper sulphate solution.

Apparatus. — Small battery jar (or beaker), two electrodes (pieces of electric light carbon) and connection wires, battery of four or more cells (or other source of electric current).

Fill the battery jar about two-thirds full of dilute copper sulphate solution. Wind the end of a piece of the wire around one end of each electrode and hang the electrodes in the solution by bending the wire over the edge of the jar (or supporting them by a strip of wood which rests across the top of the jar). Connect the ends of the wires with the battery.

Before turning on the current (or making the final connection), examine each electrode and note the absence of a deposit. Turn on the current and observe at which electrode bubbles of gas form. Let the current run about ten minutes, and then examine each electrode. Compare with their appearance before the electrolysis took place. Upon which electrode (anode or cathode) is there a deposit? What is the deposit?

Sketch the apparatus, and describe the electrolysis of copper sulphate in terms of the theory of ionization, using the sketch in your interpretation.

Experiment 97 — Electrolysis of Copper Sulphate Solution — Long Method

(Demonstration Experiment)

MATERIALS. — Copper sulphate solution, joss stick.

Fill the Hofmann apparatus (Fig. 58) full of copper sulphate solution. Connect with a reduced street current or a storage battery. Turn on the current and let it run until about 10 cc. of gas collects.

At which electrode (anode or cathode) was a gas liberated? A solid deposited? Have a glowing joss stick ready, let out a little gas, and test it with the glowing joss stick. What is the gas? What is the solid?

Answer: 1. What ions are in copper sulphate solution?

2. To what electrode does each kind of ion migrate?

3. What happens when the ions reach the electrodes?

4. What secondary action takes place at one electrode?

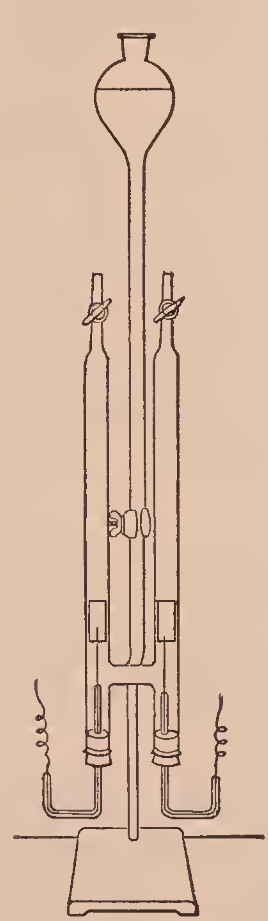


FIG. 58. — Hofmann apparatus for showing electrolysis

Experiment 98 — Electrolysis of Sodium Sulphate Solution

(Demonstration Experiment)

MATERIALS. — Sodium sulphate solution, neutral litmus solution, joss stick, wax taper.

Fill the Hofmann apparatus (Fig. 58) full of sodium sulphate solution colored with neutral litmus solution. Proceed as in Exp. 97. Let the current run until the smaller volume of gas measures about 10 cc. Observe the color of the solution in each tube; also the relative quantity of gas. Test the gases as in Exp. 49. State the result. Interpret the electrolysis of sodium sulphate by the theory of ionization.

Answer: 1. What is the name of each gas?
2. At which electrode was each gas liberated?
3. Why was the color changed in each tube?

Experiment 99 — Electrolysis of Potassium Iodide Solution (Demonstration Experiment)

MATERIALS. — Starch, potassium iodide.
APPARATUS. — Sheet of metal (tin or iron), battery of two or more cells.

Grind together in a mortar a lump of starch and a crystal of potassium iodide. Add enough water to make a thin liquid. Dip a piece of filter paper into the mixture, and spread the wet paper upon the sheet of metal. Press the end of one wire upon the metal, and draw the end of the other wire across the sheet of paper. Observe the result. If there is no result, reverse the ends of the wires. The dark marks are caused by iodine which is liberated from the potassium iodide and colors the starch.

REQUIRED EXERCISES. — 1. Describe briefly this experiment.

2. Iodine is a non-metal. Are iodine ions anions or cations? At what electrode is iodine liberated?

Experiment 100 — Dissolved Substance and Boiling Point

MATERIALS. — Sodium chloride, sugar (both finely powdered).
APPARATUS. — Thermometer, 250 cc. Erlenmeyer flask.

a. Stand a 250 cc. Erlenmeyer flask on a gauze-covered ring attached to an iron stand and clamp it about the neck. Pour 100 cc. of water into the flask, heat the water to boiling, hold the thermometer in the steam a minute or two, then lower it into the water, and observe the highest temperature. Record, and call this the boiling point.

Remove the burner, and carefully slide 10 gm. of sodium chloride from a creased paper into the flask, taking care not to let any of the solid stick to the inside of the flask. Heat to boiling, and as soon as the solution boils steadily, observe and record the temperature. In the same way add another 10 gm. portion of sodium chloride, and find the boiling point of the solution.

Compare the three boiling points. What effect has dissolved sodium chloride on the boiling point of water?

b. Proceed as in **a**, using finely powdered sugar in place of sodium chloride. Compare the general result with **a**.

Answer: 1. What effect has a dissolved substance on the boiling point of water?

2. Does the effect differ with the substance (in comparable solutions)? How? Why?

3. Does the effect differ with the quantity of the substance (in the same quantity of water)? How? Why?

4. Suppose a mole of sugar were dissolved in 1000 gm. of water, how would it affect the boiling point? Would the effect of a mole of sodium chloride be the same or different? Why?

Experiment 101 — Dissolved Substance and Freezing Point

MATERIALS. — Ice, finely powdered sodium chloride and sugar.
APPARATUS. — Bottle, thermometer.

a. Fill the bottle one-third full of cold water, drop in several small pieces of ice, and shake well. Insert the thermometer, stir, and observe the lowest temperature. Make at least three readings. Record the temperatures. Call the lowest one the freezing point of water (although it may be a little higher than the actual freezing point).

Carefully slide 10 gm. of sodium chloride into the bottle, shake a minute or two, then stir with the thermometer, and observe and record the lowest temperature. Proceed in the same way with another 10 gm. portion of sodium chloride.

Compare the lowest temperatures. Compare them with the lowest temperature of the water. What effect has dissolved sodium chloride on the freezing point of water?

b. Proceed as in **a**, using sugar in place of sodium chloride. Compare the general result with **a**.

Answer: 1. Apply 1 in Exp. 100 to the freezing point of water.
2, 3, 4. As in Exp. 100.

Experiment 102 — Colored and Colorless Ions

MATERIALS. — Solutions (dilute) of copper sulphate, copper nitrate, copper bromide, nickel chloride, nickel sulphate, cobalt chloride, cobalt nitrate, potassium dichromate, ammonium dichromate, sodium dichromate, potassium chromate, potassium permanganate — prepared for the class.

a. Observe and state the color of the copper solutions. To what ion is the color due? Give its ionic name and formula. Are the other ions in the copper solutions colored or colorless? What is a simple proof of your answer?

b. As in **a** with the nickel, etc., solutions.

REQUIRED EXERCISES. — 1. Write the formula of each substance and the corresponding ions.

2. Make a list of colored ions.
3. Make a list of 10 colorless anions. Of 10 colorless cations.

Experiment 103 — Ionization and Concentration

(Demonstration Experiment)

Apparatus. — Oblong battery jar or deep dish, carbon electrodes which reach to the bottom of the jar, separatory funnel (100 cc.), source of electric current (*e.g.* street current — direct), and two 40-watt bulbs.

a. Fill the jar nearly full of water. Insert the electrodes in the water, put the two bulbs in the circuit, make the proper connections, and turn on the current. Note the effect on the bulbs. Turn off the current.

b. Put about 50 cc. of concentrated sulphuric acid in the separatory funnel, let enough run out to fill the stem, and quickly lower the stem into the water until the end rests on the bottom of the jar. Let the acid run in slowly beneath the water. Lift out the funnel. Turn on the current. Note the effect on the bulbs. Compare with **a.**

c. Stir the acid slowly into the water and note the result, as in **b.** Compare with **a** and **b.**

Required Exercises. — 1. Describe the experiment (using a sketch of the apparatus).

2. What does this experiment show about the comparative conductivity of water, concentrated sulphuric acid, and dilute sulphuric acid?

3. In which is there greater ionization, concentrated or dilute sulphuric acid?

4. How does this experiment show the relation of ionization to concentration?

SULPHUR — SULPHIDES

(Practical Chemistry, pp. 218–227, §§ 248–258)

Experiment 104 — Physical Properties of Sulphur

Materials. — Brimstone, flowers of sulphur, lump of sulphur, thread.
Apparatus. — Graduated cylinder (500 cc.).

a. Examine and describe specimens of brimstone and flowers of sulphur.

b. Tie a thread around a lump of sulphur, and weigh it on the scales. Slip it carefully into a graduated cylinder (Fig. 59) previously filled with water to a known point. Note the increase in the volume of water. The increase in volume equals the volume of the

sulphur. Calculate the specific gravity by: Sp. gr. = Wt. of sulphur ÷ Wt. of equal vol. of water. State the result.

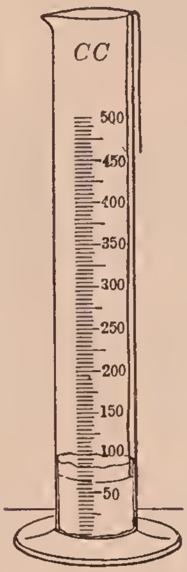


FIG. 59. — Apparatus for finding the specific gravity of sulphur

c. Fill a test tube one-fourth full of small lumps of sulphur, attach the test tube holder, and heat until all the sulphur is melted. Observe the color and consistency. Heat intensely, and observe the result. Continue to heat until the sulphur boils and then observe as before. Let the test tube cool, and save it for Exp. 108. Summarize the effects of heating sulphur.

NOTE. — If the test tube should break during the heating, extinguish the burning sulphur with sand.

Experiment 105 — Chemical Properties of Sulphur

MATERIALS. — Sulphur, iron thread.

a. Set fire to a little sulphur in a deflagrating spoon, and lower the spoon into a bottle. *Cautiously* waft the fumes toward the nose, and observe and describe the odor. What is the product of burning sulphur?

b. Fill a test tube one-fourth full of iron thread, and add an equal bulk of flowers of sulphur. Heat the part containing the sulphur — gently at first and then intensely until there is marked evidence of chemical action. Remove the test tube from the flame as soon as the action begins. Observe and describe the result. What is the name of the product of the chemical change?

Experiment 106 — Orthorhombic (Rhombic) Sulphur

MATERIALS. — Powdered roll sulphur, carbon disulphide.
APPARATUS. — Lens.

Put about 2 gm. of powdered roll sulphur in a test tube and add about 5 cc. of carbon disulphide — remember to keep the carbon disulphide away from flames. Shake until most of the sulphur is dissolved, then filter the solution (or pour the clear liquid) into an evaporating dish to crystallize. Stand the dish in the hood or out of doors, where there is no flame and where the offensive vapor will be quickly removed. Allow the liquid to evaporate; watch the crystallization toward the end, if convenient, and remove and dry the best crystals.

Examine the crystals with the eye and with a lens. Note the color, luster, and shape. Draw the best shaped one.

Experiment 107 — Preparation of Monoclinic Sulphur

MATERIALS. — Sulphur (roll), carbon disulphide.

a. Fix a folded filter paper firmly in a funnel, and place the funnel in a test tube which stands in a rack. Fill a test tube two-thirds full of roll sulphur, heat it at first throughout its length, and gradually increase the heat until all the sulphur is melted. Then quickly pour it upon the filter paper. Let it cool until crystals appear just below the surface, and then pour out the remaining melted sulphur at once into a dish of water.

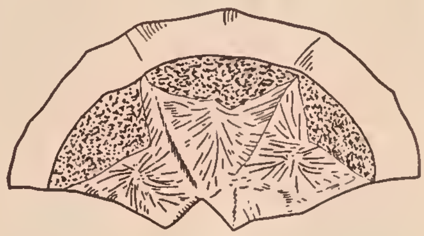


FIG. 60. — Monoclinic sulphur

Remove the paper and adhering sulphur, and cut, or break, open the cone of crystallized sulphur (Fig. 60). Observe and record the properties of the crystals, especially the shape, size, color, luster, and brittleness. Allow the best crystals to remain undisturbed for a day or two; then examine again, and record any marked changes.

Experiment 108 — Amorphous (Plastic) Sulphur

MATERIALS. — Sulphur, or test tube and contents from Exp. 104 c.

Put a few pieces of roll sulphur in a test tube, or use the test tube saved in Exp. 104 c, heat carefully until the sulphur boils, and then quickly pour the molten sulphur into a dish of cold water. This is the plastic variety of amorphous sulphur. Note its properties. Compare with orthorhombic and monoclinic sulphur.

Preserve, and examine it after twenty-four hours. Describe it, and compare its properties with those previously observed. Pulverize a small piece and test its solubility in carbon disulphide. State the result.

Experiment 109 — Hydrogen Sulphide — Short Method

MATERIALS. — Ferrous sulphide, dilute hydrochloric acid, lead nitrate solution.

APPARATUS. — As in Fig. 61 for d.

Caution. — Perform this experiment in the hood.

a. Slip a small piece of ferrous sulphide carefully into a test tube, add 5 cc. of dilute hydrochloric acid, and cautiously note the odor of the gas. Describe the odor.

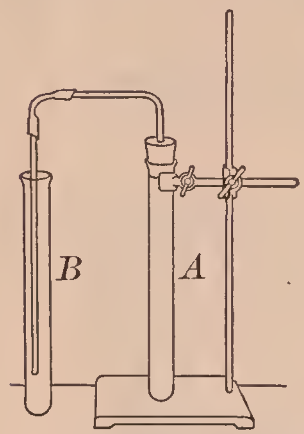


FIG. 61. — Apparatus for preparing hydrogen sulphide water

b. Wet a piece of filter paper with lead nitrate solution and hold it in the escaping gas. Note the change in color. Into what lead compound has the lead nitrate been changed?

c. Add a little more ferrous sulphide and dilute hydrochloric acid to the test tube, and hold a lighted match at the mouth of the tube. Observe the result. Cautiously note the odor of the gas. What is the gas?

d. Arrange an apparatus as in Fig. 61. Fill *B* half full of water. Put ferrous sulphide and dilute hydrochloric acid in the test tube *A* and let the gas bubble through the water in the test tube *B* for a few minutes. Use the solution in Exp. 111. Cork it tightly unless it is to be used soon.

Experiment 110 — Hydrogen Sulphide — Long Method

MATERIALS. — Ferrous sulphide, dilute hydrochloric acid.
APPARATUS. — As in Fig. 62; stoppered bottle.

Caution. — Hydrogen sulphide is a poisonous gas and has an offensive odor. It should not be inhaled nor allowed to escape into the laboratory. All experiments with hydrogen sulphide should be performed in the hood.

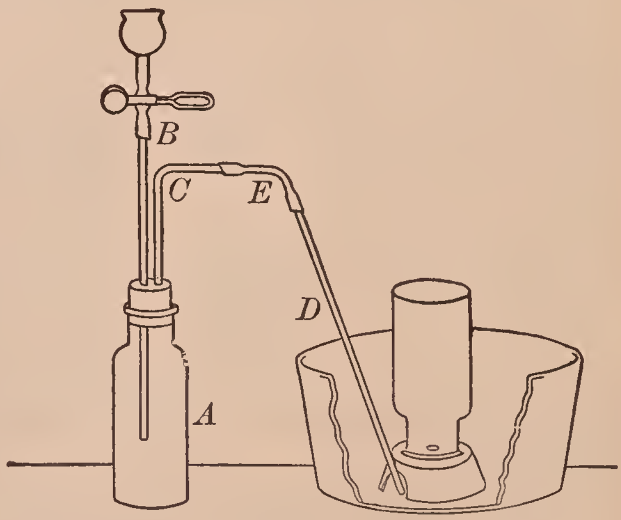


FIG. 62. — Apparatus for preparing hydrogen sulphide

I. Preparation. — Construct and arrange an apparatus like that shown in Fig. 62. Put 10 gm. of coarsely powdered ferrous sulphide in the bottle *A*, insert the stopper tightly, and adjust the apparatus so that the end of the delivery tube will be under the support of the pneumatic trough. Introduce a little dilute hydrochloric acid through the dropping tube. Hydrogen sulphide is rapidly evolved. If the

evolution of gas slackens or stops, add more hydrochloric acid. Collect three bottles, removing each as soon as full and covering tightly with a piece of dry filter paper. Set aside until needed. When all the bottles have been filled with gas, proceed at once with **II**.

II. Properties. — **a.** Waft a very little of the gas *cautiously* toward the nose, and describe the odor. This odor is characteristic of hydrogen sulphide, and is a decisive test. Has the gas color?

b. Test the gas from the same bottle with both kinds of moist litmus paper. Is hydrogen sulphide acid, alkaline, or neutral?

c. Hold a lighted match at the mouth of the same bottle. Observe the color of the flame. Observe cautiously the odor of the product of the burned gas; to what compound is the odor due? What, then, is one constituent of hydrogen sulphide?

d. Burn another bottle of hydrogen sulphide and hold a cold, dry bottle over the burning gas. What additional experimental evidence does this result give regarding the composition of hydrogen sulphide?

e. Pour several drops of concentrated nitric acid into a bottle of hydrogen sulphide, cover, and shake. Note the solid product. What is it? Explain its formation.

Required Exercises.— 1. Summarize briefly the properties of hydrogen sulphide gas.

2. State the experimental evidence of its composition.

Experiment 111 — Preparation and Properties of Sulphides

Materials. — Hydrogen sulphide water, clean copper wire, clean sheet lead, bright silver coin, lead oxide (litharge); solutions of lead nitrate, arsenic trioxide (in hydrochloric acid), tartar emetic, zinc sulphate, cadmium nitrate, silver nitrate, and mercuric chloride (*Poison!*).

a. Obtain a bottle half full of hydrogen sulphide water, and hang (by a wire or thread) inside the bottle (1) a clean copper wire, (2) a clean strip of lead, and (3) a bright silver coin. Describe the result in each case. The products are sulphides of the respective metals; give the name and formula of each.

b. Put a little litharge — the brownish yellow oxide of lead — in a test tube, cover it with hydrogen sulphide water, and warm gently. The product is lead sulphide. Describe it.

c. Add hydrogen sulphide water to lead nitrate solution. Describe the product. What is the name of the product?

d. Proceed as in **c** with the arsenic solution. Observe the color of the product. Compare with **c**. What is the product?

e. Proceed as in **c** with the tartar emetic solution. Tartar emetic

is a compound of antimony. Observe the color of the product. Compare with **c** and **d**. What is the product?

f. Proceed as in **c** with the zinc sulphate solution. Observe the color of the product. Compare with **c**, **d**, and **e**. What is the product?

g. Proceed as in **c** with solutions of cadmium nitrate, silver nitrate, and mercuric chloride (*Poison!*). Use separate test tubes. Observe the color in each case, and name the product.

Required Exercises. — 1. Prepare a list of sulphides, including the name, formula, and color of each.

2. Write the equation for the interaction of (*a*) lead nitrate and hydrogen sulphide, (*b*) arsenic trichloride and hydrogen sulphide.

3. Write the equations in 2 in ionic form.

4. How could hydrogen sulphide be used to identify the metallic part of many salts?

5. Suggest a test for sulphide ions.

SULPHUR DIOXIDE — SULPHUROUS AND SULPHURIC ACIDS — SULPHITES AND SULPHATES

(Practical Chemistry, pp. 229–241, §§ 259–276)

Experiment 112 — Sulphur Dioxide — Short Method

Materials. — Sulphur, joss stick, litmus paper, potassium permanganate solution (dilute), colored flower.

Apparatus. — Bottle fitted with cork.

Caution. — Perform this experiment in the hood.

Fill a deflagrating spoon with sulphur, set it afire, and lower the spoon into a bottle. In a minute or two, remove the spoon, and cover the bottle with a glass plate or (tightly) with a piece of filter paper. In the same way prepare and cover two more bottles of sulphur dioxide.

a. Cautiously note the odor. After the smoke (which is not sulphur dioxide) has settled, observe whether the gas has any color. Is it heavier or lighter than air? Save for **b**.

b. Hold a blazing joss stick or a burning match in the bottle of gas saved from **a**. Does the gas burn? Does it support combustion?

c. Stand the second bottle of gas mouth downward in a vessel of water (*e.g.* pneumatic trough). Shake, still keeping the mouth submerged. Observe the result. What does the result show about

the solubility of sulphur dioxide in water? Slip a piece of filter paper under the mouth of the bottle, remove, invert, and test the liquid with litmus paper. State the result. To what compound is the result due? Save for **d**.

d. Pour a few drops of very dilute potassium permanganate solution into the bottle saved from **c**, and shake well. Compare the color of the two liquids. If the result is not satisfactory, repeat, and use a bottle full of sulphur dioxide to which only 5 cc. of water has been added. Explain the chemical change.

e. Moisten a few petals of a colored flower with water, put them in the third bottle of sulphur dioxide, and insert the cork. Observe and describe any change in color.

Experiment 113 — Sulphur Dioxide and Sulphurous Acid

MATERIALS. — Sodium sulphite, dilute sulphuric acid, litmus paper, joss stick, colored flower, potassium permanganate solution.

APPARATUS. — As in Fig. 63.

Caution. — Perform this experiment in the hood.

I. Preparation. — a. Sulphur Dioxide. — Put about 10 gm. of sodium sulphite in the flask, and insert the stopper with its tubes. Adjust the apparatus as shown in Fig. 63. Fill the cup with dilute sulphuric acid, press the pinch-clamp a little, and let the acid flow *drop by drop* upon the sodium sulphite. Sulphur dioxide is evolved and passes into the bottle, which should be removed when full, as previously described. Warm gently, if the action slackens. Moist blue litmus paper held for an instant at the mouth of the bottle will show (by change in color) when the latter is full. Collect two bottles of gas, cover each tightly with a piece of filter paper or a glass plate, and set aside until needed for **II a**.

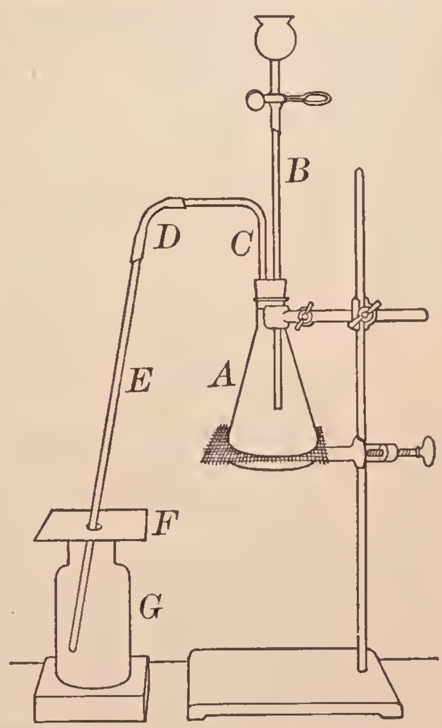


FIG. 63. — Apparatus for preparing sulphur dioxide and sulphurous acid

b. Sulphurous Acid. — As soon as the second bottle of gas has been removed and covered, put in its place a bottle one-fourth full of water. Adjust its height (if necessary) by wooden blocks, so that the end of the delivery tube is just above the

surface of the water. Continue to add the acid and to heat at intervals. Shake the bottle occasionally. When **II a**, etc., have been done, proceed with this solution as in **III a**, etc.

II. Properties of Sulphur Dioxide Gas. — a, b, c, d, e. Proceed as in Exp. 112 **a, b, c, d, e.**

III. Properties of Sulphurous Acid. — a. Observe the odor and the taste *cautiously*. State each result.

b. Apply the litmus test, and state the result.

c. Drop a short piece of magnesium ribbon into 10 cc. of the solution. Warm slightly if there is no action. State the result.

d. Add a few drops of potassium permanganate solution to 5 cc. of sulphurous acid. Observe and state the result. What chemical change has the sulphurous acid undergone?

e. Put about 10 cc. of sulphurous acid in an evaporating dish, support the dish on a gauze-covered ring attached to an iron stand, heat in the hood, gradually, and note the odor of the liberated gas. Blow the gas out of the dish frequently, and then smell of the liquid. Boil until most of the liquid is evaporated, and test the remainder with litmus paper. What effect has heat on sulphurous acid?

f. Put 10 cc. of sulphurous acid into a test tube, cover loosely, and let it stand exposed to the air for a day or two. Add 10 cc. of water, boil for a minute or two, and test as in Exp. 115 **b**. State and explain the result.

g. Put 10 cc. of sulphurous acid in a test tube, add 2 cc. of concentrated nitric acid, and boil gently for a minute or two. Add about 10 cc. of water, shake, and test as in Exp. 115 **b**. State and explain the result. Compare with **d** and **f**.

Experiment 114 — Properties of Sulphuric Acid

Materials. — Concentrated sulphuric acid, thin stick of wood, sugar.

Apparatus. — Graduated cylinder (100 cc.), hydrometer for heavy liquids.

Caution. — Concentrated sulphuric acid is a corrosive liquid. Do not spill it on the flesh or clothing.

a. Weigh a 25 cc. graduated cylinder, pour in concentrated sulphuric acid to a convenient height (*e.g.* 20 cc.) and weigh again. Read the exact volume of the acid. From the weight and volume of the acid, calculate its specific gravity.

Find the specific gravity of a sample of the same acid by reading the hydrometer which floats in the acid (Fig. 64). (This apparatus should be arranged for the class by the Teacher. See Exp. 38.)

b. Add an equal volume of concentrated sulphuric acid to a test

tube one-fourth full of water, shake well, and observe at once the change in temperature by holding the tube in the hand. Save the solution for **c** and **d**.

c. Dip a glass rod into the sulphuric acid from **b** and write some letters or figures on a sheet of paper. Move the paper back and forth slowly over a low flame, taking care not to set fire to the paper. As the water evaporates the dilute acid becomes concentrated. Observe and describe the result. (Paper is largely a compound of carbon, hydrogen, and oxygen, and the hydrogen and oxygen are present in the proportion to form water.) Explain the general chemical change in this experiment.

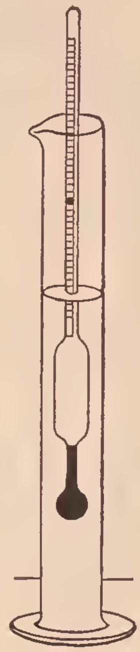


Fig. 64. — Finding the specific gravity of sulphuric acid with the hydrometer

d. Warm the acid in the test tube saved from **b**, stand a stick of wood in the acid, and allow it to remain for fifteen minutes or more. Then remove the stick and wash off the acid. Describe and explain the change in the wood.

e. Put 5 gm. of sugar in an evaporating dish, add just enough warm water to make a thick sirup, and stand the dish on a block of wood (or in the sink). Cautiously pour 5 or 10 cc. of concentrated sulphuric acid upon the liquid. Stand back and observe the result. Explain the result.

Experiment 115 — Tests for Sulphuric Acid, Sulphates (Soluble and Insoluble), and SO_4-ions

Materials. — Sulphuric acid, sodium sulphate, barium chloride solution, calcium sulphate, charcoal, powdered charcoal, silver coin.

Apparatus. — Blowpipe and blowpipe tube.

a. Sulphuric Acid. — Recall a test for concentrated sulphuric acid. How could the same test be utilized for dilute sulphuric acid?

b. Sulphuric Acid and Soluble Sulphates, *i.e.* solutions containing SO_4-ions. — Add barium chloride solution to the solution of the acid or the sulphate, and boil with dilute hydrochloric acid. If no sulphur dioxide gas is liberated and an insoluble precipitate remains, the original solution contained SO_4-ions.

c. Insoluble Sulphates. — Proceed as in Exp. 134 **A b**, using calcium sulphate (or any sulphate insoluble in water).

CARBON — CARBONIC ACID — CARBONATES — OXIDES

(Practical Chemistry, pp. 244–258, §§ 277–295)

Experiment 116 — Properties of Graphite

MATERIALS. — Graphite, thread, articles for **d**.
APPARATUS. — Graduated cylinder (500 cc.), test wire.

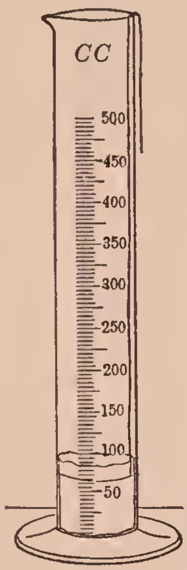


FIG. 65. — Apparatus for finding the specific gravity of graphite

a. Rub a piece of graphite with the finger, and describe the feeling. Draw a piece slowly across a sheet of paper, and state the result.

b. Proceed with a lump of graphite as in Exp. 104 **b** (Fig. 65). Record the result.

c. Wind the end of a test wire around a small piece of graphite and hold it in the hottest part of the flame for five or ten minutes (Fig. 66). State the result.

d. Examine stove polish, plumbago crucible, core of a lead pencil, electrodes, or lubricant. How would you test them for graphite?

Experiment 117 — Properties of Charcoal

MATERIALS. — Wood charcoal (lump and powder), animal charcoal, copper wire, crucible, vinegar, hydrogen sulphide solution.
APPARATUS. — Test tube fitted with a cork, crucible and support.

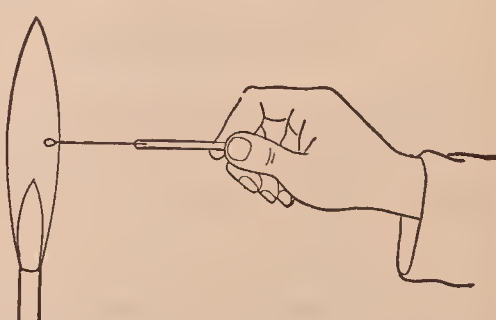


FIG. 66. — Apparatus for heating graphite in a hot flame

Wood charcoal. — Wind the end of a test wire around a piece of charcoal, hold it in the flame, and observe the result, especially the ease or difficulty of ignition, presence or absence of flame and smoke, formation of ash. Compare with graphite (Exp. 116 **c**).

Animal charcoal. — **a.** Cover the bottom of a crucible with animal charcoal, stand the crucible on a triangle and heat intensely for about half an hour. Examine the residue. What is it?

b. Fill a test tube one-fourth full of powdered animal charcoal (refer to Fig. 5). Add 10 cc. of hydrogen sulphide solution, and

cork securely. Shake well. After ten minutes, remove the stopper and smell of the contents. Is the odor much less offensive? What property of animal charcoal does this experiment illustrate?

c. Fill a test tube one-fourth full of powdered animal charcoal, (refer to Fig. 5), add 10 cc. of vinegar, shake thoroughly for a minute, and then warm gently. Filter through a wet paper. Compare the colors of the filtrate and the original vinegar. Describe briefly. What property of animal charcoal does this experiment illustrate?

Experiment 118 — Testing for Carbon

Test various substances for carbon by heating in a test tube or a crucible, as in Experiment 11 e. State the result.

Experiment 119 — Reduction of Copper Oxide by Carbon

MATERIALS. — Powdered copper oxide, powdered wood charcoal, calcium hydroxide.
APPARATUS. — As in Fig. 67, lens.

Grind together in a mortar about 5 gm. of copper oxide and 1 gm. of wood charcoal. Put the mixture on a creased paper (refer to Fig. 5) and slip it into the test tube *A*. Fill the bottle *B* half full of calcium hydroxide. Arrange the apparatus as in Fig. 67.

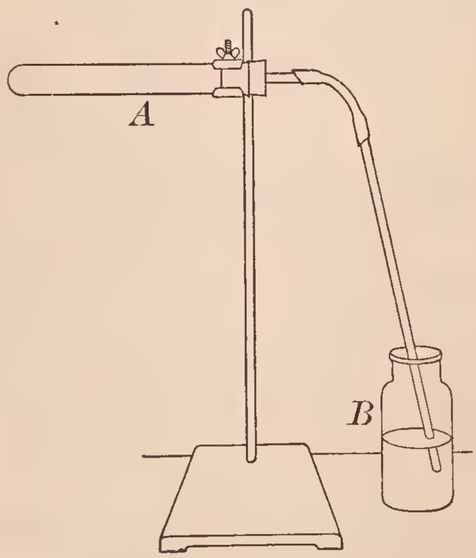


FIG. 67. — Apparatus for reducing copper oxide with carbon

Heat the test tube gently at first, and adjust the height so the evolved gas will bubble through the calcium hydroxide in *B*. Heat intensely for about ten minutes, moving the burner along the part of the test tube that contains the mixture. Observe the change in the calcium hydroxide. To what is the change due?

As soon as a definite change is noted in *B*, remove the end of the delivery tube from *B*, and stop heating. Let the test tube cool and pour the contents into a mortar. Examine it carefully with the eye and with a lens. What is detected besides carbon?

Interpret the chemical change and write the equation for the reaction.

Experiment 120 — Carbonic Acid

(Demonstration Experiment)

MATERIALS. — Solutions of sodium hydroxide and phenol-phthalein.

APPARATUS. — Carbon dioxide generator with washing tube.

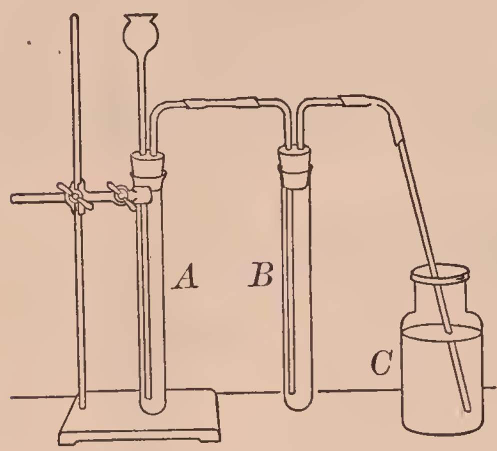


FIG. 68. — Apparatus for preparing and washing carbon dioxide

Construct and arrange the carbon dioxide generator like that shown in Fig. 68. (A bottle may be used in place of the test tube *A*.) Put marble chips in *A* and water in *B* (to wash the gas free from acid). Use dilute hydrochloric acid. Fill a bottle half full of water, add a few drops of phenol-phthalein solution and just enough sodium hydroxide solution to color the liquid a faint pink (after shaking). Pass a *slow* current of carbon dioxide from the generator through the liquid in the bottle until a definite change is produced in the absorbing liquid. Describe and explain it.

Experiment 121 — Normal and Acid Calcium Carbonate

(Demonstration Experiment)

APPARATUS. — Carbon dioxide generator (as in Exp. 120).

Fill the bottle *C* one-fourth full of calcium hydroxide solution and pass carbon dioxide through it until the precipitate at first formed disappears. Filter, if the liquid is not perfectly clear. Put 15 cc. into a test tube and heat gently. Observe all the changes. State the results of heating the clear solution.

REQUIRED EXERCISES. — 1. What is the name of the first precipitate?

2. Into what soluble compound was this precipitate formed by interaction with carbon dioxide?

3. Into what was the soluble compound formed by heating?

4. Write equations for (1) preparation of carbon dioxide, (2) formation of the precipitate, (3) formation of the soluble compound, (4) decomposition of the soluble compound.

Experiment 122 — Testing for Carbonates

MATERIALS. — Barium hydroxide solution, baking soda, washing soda, baking powder, native chalk, tooth powder, white lead, whiting, old mortar (or plaster), "unknowns."

Put some of the fine solid in a test tube, add a little water and dilute hydrochloric acid, and shake. Then hold a glass tube, which has been dipped into barium hydroxide solution, inside the test tube for a minute or two about 3 cm. above the mixture. If the action is not marked, gently warm the test tube. State the result in each case.

Experiment 123 — Carbon Monoxide

(Demonstration Experiment)

MATERIALS. — Oxalic acid, calcium hydroxide solution.
APPARATUS. — As in Fig. 69.

Caution. — Carbon monoxide and oxalic acid are poisonous. Hot sulphuric acid is dangerous. Perform this experiment in the hood with unusual care.

I. Preparation. — Put 10 gm. of oxalic acid in the flask *A* (Fig. 69), and add 25 cc. of concentrated sulphuric acid. Put enough calcium hydroxide solution in *B* to cover the end of the tube *E*. Arrange the apparatus as in Fig. 69. The end of *H* should rest on the bottom of the pneumatic trough just beneath the hole in the support.

Heat the flask *A* gently, and carbon monoxide will be evolved. Collect all the gas, but *do not* use the first bottle, covering the bottles with glass plates as they are filled, and setting them aside temporarily. When the last bottle has been collected and covered, loosen the stopper in *B*, and remove the end of *H* from the water in the trough. Proceed at once with **II.**

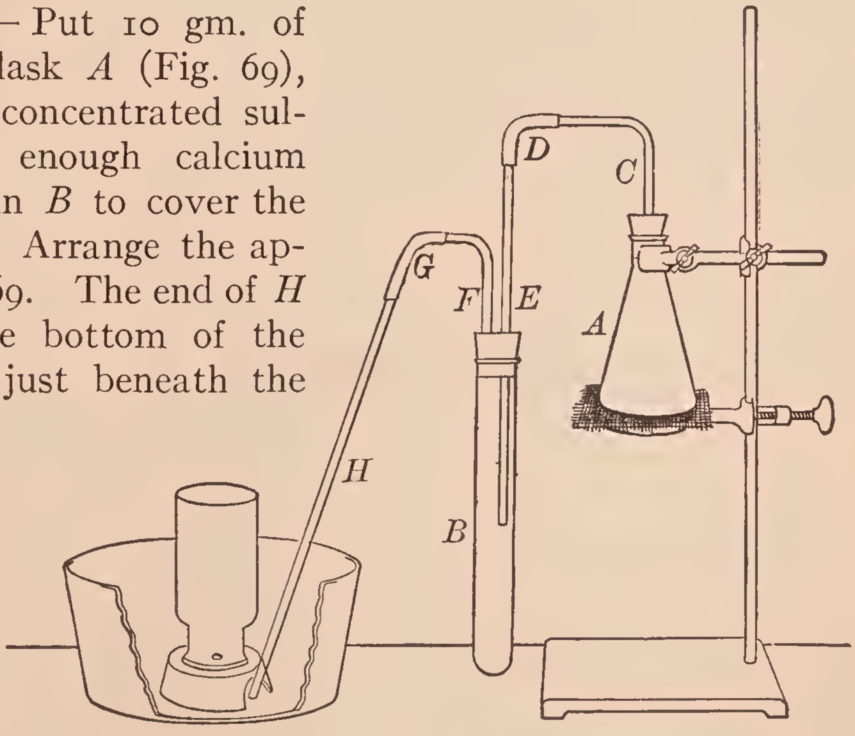


FIG. 69. — Apparatus for preparing carbon monoxide

II. Properties. — **a.** Note that the gas is colorless.

b. Hold a lighted match at the mouth of a bottle. Note the flame, especially its color. After the flame has disappeared, drop a lighted match into the bottle. Describe the result. Draw a conclusion and verify it by **c.**

c. Burn another bottle of gas, note the flame again, and after the flame has disappeared pour calcium hydroxide solution into the bottle and shake. Explain the result.

REQUIRED EXERCISES. — 1. Describe briefly the preparation of carbon monoxide.

2. Summarize the observed properties of carbon monoxide.

3. What gas besides carbon monoxide was produced in **I**?

FUELS — ILLUMINATING GAS — FLAME

(Practical Chemistry, pp. 260–288, §§ 296–338)

Experiment 124 — Composition of Fuels

MATERIALS. — Soft coal, wood, alcohol, gasolene, calcium hydroxide solution.

APPARATUS. — Crucible (porcelain or iron).

a. Put a little powdered soft coal in a test tube, attach the holder, and heat intensely in the flame (Fig. 70). Note the formation of moisture and volatile matter (smoke). Describe the result.

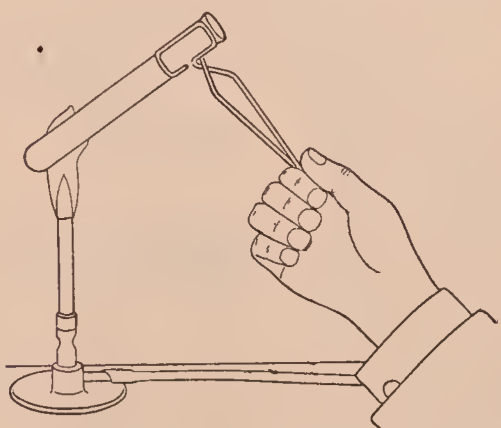


FIG. 70.— Heating soft coal to detect volatile matter

b. Optional. Put a little powdered soft coal in a crucible (porcelain or iron), support the crucible on a triangle (Fig. 71), and heat intensely. After the smoking has stopped, note the black, hard mass of fixed carbon. Continue to heat until the carbon has disappeared. The residue is ash (or ashes). Describe it.

c. Proceed as in **a**, using shavings or small pieces of wood. Describe the result. Continue to heat until the carbon is burned. Is ash left?

d. Put several drops of alcohol in a dish, set it afire, and hold a cold, dry bottle over the flame. When the flame goes out, remove the bottle, and stand it mouth upward on the desk. What is the film inside the bottle? Add calcium hydroxide solution, cover the bottle with the hand, shake well, and note the result. What do these two tests show about the composition of alcohol?

e. Proceed as in **d**, using gasolene instead of alcohol (Care!)

f. Hold a cold dry bottle for a minute or two over a small Bunsen flame. Note the obvious product. What is it? What is the other

product? Verify your answer by a simple test. Apply the last question asked in **d**.

Experiment 125 — Analysis of Coal

OBJECT. — To find the per cent of moisture, volatile matter, fixed carbon, and ash in a sample of coal.
MATERIAL. — Coal (powdered very fine).
APPARATUS. — 2 crucibles, 2 covers, triangle, drying oven.

NOTE. — Parts of this experiment may be assigned to sections or individuals. To save time, **a** may be omitted and the experiment started with **b**; see directions in **b**. This experiment may be deferred until § 299 in the author's *Practical Chemistry* is studied.

As in previous experiments, copy first the forms of RECORD; enter the weights as soon as weighings are made.

a. Moisture. — Weigh a clean, dry porcelain crucible and cover accurately on the balance. Remove the crucible from the balance pan, and slip about 2 gm. of the powdered coal into the crucible, taking care not to leave any dust on the edges or sides of the crucible. Weigh (with the cover).

Put the crucible, uncovered, in an oven and heat for about an hour to 105° C. (104–107). Cool, and weigh with the cover. The loss in weight is the weight of the moisture. Save the crucible and contents for **b**. Calculate the per cent of moisture and enter it in RECORD — I.

RECORD — I

Weight of crucible, cover, and coal before heating . . .	gm.
Weight of crucible and cover	________gm.
Weight of coal	gm.
Weight of crucible, cover, and coal before heating . . .	gm.
Weight of crucible, cover, and coal after heating	________gm.
Weight of moisture	gm.
Per cent of moisture	per cent

b. Volatile Matter. — If **a** has been done, use the crucible and contents. If **a** was omitted or is being done, start **b** with a new portion of coal. Enter the weights in RECORD — II. The loss in this case is the total volatile matter (that is, other volatile matter besides moisture).

Place the covered crucible on a triangle which rests on a ring attached to an iron stand (Fig. 71). Heat gently at first, and then intensely for eight minutes, or for two or three minutes after the gases cease to burn between the crucible and cover. Cool the crucible slowly, and weigh (with the cover). The loss in weight is the volatile matter (combustible, if the crucible from **a** was used, total, if a new portion was used). Save the crucible and contents for **c**. Calculate the per cent of total volatile matter (and if **a** was done, the per cent of combustible volatile matter) and enter in the proper place in Record — II.

Record — II

Weight of crucible, cover, and coal before heating . . .	gm.
Weight of crucible and cover	gm.
Weight of coal	gm.
Weight of crucible, cover, and coal before heating . . .	gm.
Weight of crucible, cover, and contents after heating . .	gm.
Weight of volatile matter	gm.
Per cent of volatile matter	per cent

c. Fixed carbon and ash. — If the crucible and contents from **b** are used, proceed at once to heat the *uncovered* crucible as in the next paragraph. If **b** was not done or the crucible is not available, start with a new portion as in **a**; heat the covered crucible containing the new portion of coal gently until most of the volatile matter has been expelled. Then remove the cover and proceed as in the next paragraph. Enter the weights in the proper places in Record — III.

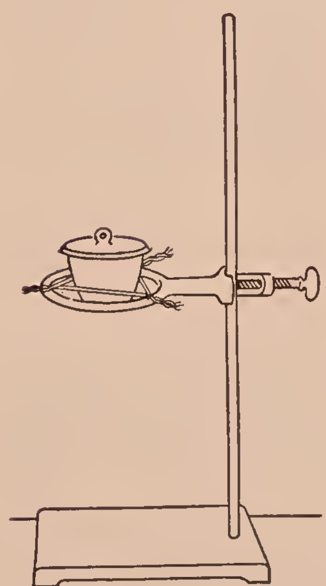


Fig. 71. — Apparatus for determining the volatile matter in coal

Incline the uncovered crucible slightly (Fig. 72), heat gently at first and then intensely until all the carbon has been burned; if any carbon remains on the inside of the cover, burn it off very carefully. Cool and weigh the covered crucible. The final weight of the substance in the crucible is the weight of the ash. Calculate the per cent of ash. Calculate also the per cent of fixed carbon, utilizing the results in **a** and **b** for this calculation and enter in Record — III.

Record — III

Weight of crucible, cover, and coal before heating . . .	gm.
Weight of crucible and cover	————gm.
Weight of coal	gm.
Weight of crucible, cover, and ash. I gm. II . . .	gm.
Weight of crucible and cover	————gm.
Weight of ash	gm.
Per cent of ash	per cent
Weight of coal	gm.
Weight of volatile matter (total)	————gm.
Weight of fixed carbon and ash	gm.
Weight of ash	————gm.
Weight of fixed carbon	gm.
Per cent of fixed carbon	per cent

Experiment 126 — Properties of Gasolene

Apparatus. — Hydrometer (specific gravity — direct reading) for liquids lighter than water, tall jar, medicine dropper, bottle fitted with cork.

Caution. — Gasolene vapor catches fire quickly. Keep all flames away except as the experiment requires.

a. Pour a few drops of gasolene into an evaporating dish. Note the odor. Cautiously bring a Bunsen flame near the surface of the liquid. Observe and state the result.

b. Put a few drops of gasolene on a glass plate and note the result. Is gasolene volatile? Very volatile?

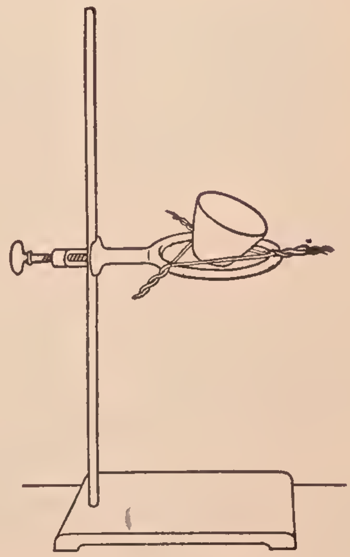


Fig. 72. — Apparatus for determining the fixed carbon in coal

c. Warm a 250 cc. bottle. Drop in (from a medicine dropper or a pointed glass tube) two or three drops of gasolene. Insert the cork and fill the bottle with vapor by rolling and shaking it. Uncork it, and hold a blazing joss stick at the mouth for an instant. Note the result. If the result is not striking, repeat with five or six drops of gasolene. State the result. Does gasolene explode? What does explode?

d. Determine the specific gravity of one or more samples of gasolene with the hydrometer (Fig. 73) as in Exp. 38.

Experiment 127 — Properties of Kerosene

APPARATUS. — As in Fig. 74, thermometer.

a, b, c, d. Proceed as in Exp. 126 **a, b, c, d.** Compare the corresponding results of each experiment.

e. Determine the flashing point of kerosene with the apparatus shown in Fig. 74. Fill the large beaker nearly full of water. Suspend the small beaker in the water by winding a copper wire around the top and twisting the ends of the wire around the large beaker just below the rim. Stand the large beaker on a gauze-covered ring or a piece of asbestos board. Fill the small beaker nearly full of kerosene. Clamp the thermometer so that the bulb is submerged in the kerosene.

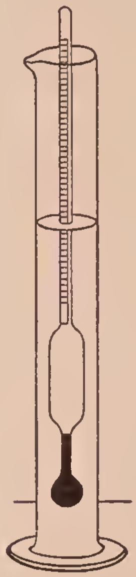


FIG. 73. — Apparatus for finding the specific gravity of gasolene

Heat the water gently and at intervals slowly pass a lighted match or a blazing joss stick about half an inch above the surface of the kerosene; when the vapor catches fire and a flash passes down to the surface of the kerosene, read and record the temperature. Let the water cool somewhat, and repeat the test.

The lowest temperature at which the flame, caused by the burning vapor, passes completely over the surface may be accepted as the flashing point of kerosene.

NOTE. — The legal flashing point of commercial kerosene varies, but in most states it is about 44° C.

Experiment 128 — The Principle of the Davy Safety Lamp

a. Press a wire gauze down upon a Bunsen flame. Where is the flame? Remove the gauze, let it cool (or use another gauze), lower it upon the flame, and hold a lighted match just above the gauze. Now where is the flame?

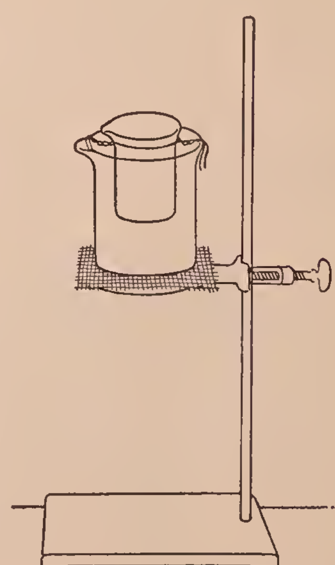


FIG. 74. — Apparatus for finding the flashing point of kerosene

b. Extinguish the flame. Turn the gas on full, hold the gauze in the escaping gas, about 15 cm. (6 in.) above the top of the burner, and thrust a lighted match into the gas above

the gauze. Move the gauze slowly back and forth. Where is the flame? Lower the gauze slowly and describe the final result.

c. Hold the gauze in the flame in one position for a minute or two. Where is the flame at the end of this time? Why?

Experiment 129 — Illuminating (Coal) Gas

MATERIALS. — Soft coal, litmus paper, lead nitrate solution.
APPARATUS. — As in Fig. 75.

Fill the test tube two-thirds full of coarsely powdered soft coal, insert the stopper with its tube, and clamp the test tube carefully to the iron stand as shown in Fig. 75. Heat the whole tube gently at first, gradually increase the heat, and finally heat intensely the part containing the coal.

a. As soon as the gas begins to escape, hold at the end of the tube a piece of filter paper which has been moistened with lead nitrate solution; observe the effect upon the paper. The discoloration is caused by lead sulphide which is produced by the interaction of lead nitrate and the sulphides in the liberated gas.

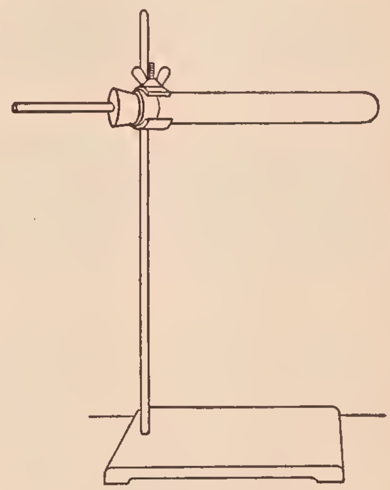


FIG. 75. — Apparatus for preparing coal gas

b. Lay a piece of wet red litmus paper on the end of the tube and continue to heat intensely; wet the paper, if it dries. Observe any change in the color of the litmus paper. To what class of compounds in the gas is the change due?

c. Heat intensely, and light the gas at the end of the tube. Observe and describe the flame.

d. Discontinue heating, let the apparatus cool somewhat, disconnect, and break open the test tube. Examine the contents. State the properties of both solid and liquid products; what is the name of each?

Experiment 130 — Testing Illuminating Gas

MATERIALS. — Solutions of calcium hydroxide, lead nitrate, potassium permanganate (very dilute).

a. Test samples of illuminating gas for carbon dioxide, sulphides (Exp. 129 a), and ammonia. State the results.

b. Suggest a test for moisture. Submit the details to the Teacher, before proceeding.

c. Fill a bottle with illuminating gas as follows: Invert a bottle over a Bunsen burner (not lighted), turn on the gas and slowly displace the air with illuminating gas. When the bottle is full, turn off the gas, stand the bottle upright, quickly pour in about 5 cc. of very dilute (faint pink) potassium permanganate solution, cover with the hand, and shake well. Note the change in the color of the liquid. The change is caused by the illuminants (ethylene, etc.).

Experiment 131 — Illuminating Gas Flame

Materials. — Calcium hydroxide solution.
Apparatus. — Gas burner (Fig. 76) or tip, glass tube.

a. Examine a gas burner tip, noting especially the slit.

b. If an ordinary gas burner is not available, attach the tip to a rubber tube and slip the tube over the top (or just inside) of a Bunsen burner. Light the gas. Note the yellow and black parts. Turn off the gas slowly until the flame is very small and note the change in the size of the parts, and finally the black and the blue parts. Turn on the gas slowly and note the change in the size of the parts. Describe these changes. (See Fig. 76.)

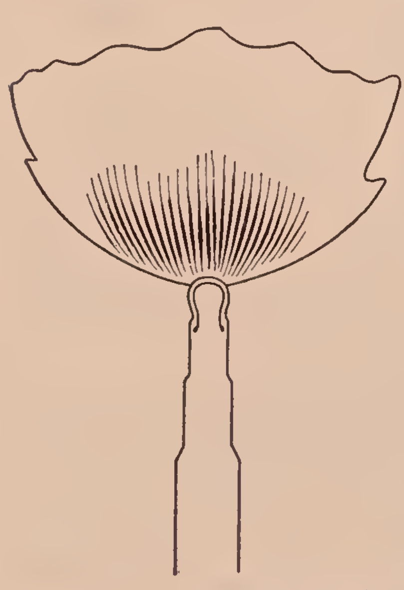


Fig. 76. — Illuminating gas flame

c. Hold a glass tube in the upper part of the yellow flame. Note the deposit on the tube. What is it? Where did it come from? Lower the flame and hold a cold dry bottle low down almost upon the flame. Is a deposit formed? If so, what is it and why was it formed?

d. Hold a cold dry bottle mouth downward just over the flame. What is the deposit inside the bottle? Pour about 10 cc. of calcium hydroxide solution into the bottle, and shake. Describe and explain the result. What are the two products of the combustion of illuminating gas?

Experiment 132 — Candle Flame

Materials. — Candle, piece of stiff paper, calcium hydroxide solution, lead pencil, copper wire (15 cm. or 6 in. long).

Stick a short candle to a block of wood by means of a little melted candle wax.

a. Hold a cold, dry bottle over the lighted candle. What is the product seen inside the bottle? What is its source? Remove the bottle, pour in a little calcium hydroxide solution, and shake. Describe and explain the result. What are the two main products of a burning candle?

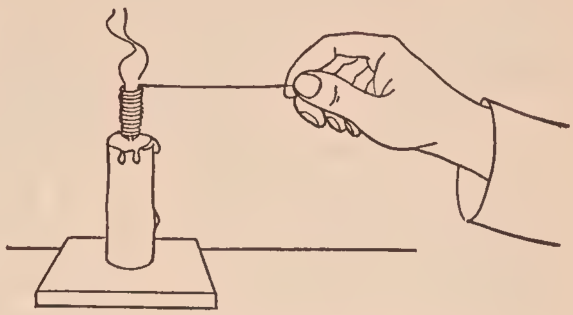


Fig. 77. — Effect of cooling a candle flame

b. Blow out the candle flame, and immediately hold a lighted match in the escaping smoke. Does the candle relight? Why? What is the general nature of this smoke? How is it related to the candle wax?

c. Press a piece of stiff paper for an instant down upon the steady candle flame almost to the wick. Repeat several times with different parts of the paper. What do the marks on the paper show about the structure of the flame?

d. Roll one end of the copper wire around a lead pencil to form a spiral about 2 cm. (or 1 in.) long. Press the spiral down slowly upon the candle flame (Fig. 77). Cool the wire and repeat. What is the result? Why?

Optional Exercises. — 1. Draw a candle flame, showing the parts.

2. Is there any essential difference between a candle and a gas or a lamp flame?

3. Why do candles and lamps often smoke?

Experiment 133 — Bunsen Burner and Bunsen Burner Flame

Materials. — Powdered wood charcoal, pin, copper wire.

a. Take apart a Bunsen burner and study the construction. Write a short description of the burner. Sketch the essential parts.

b. Close the holes at the bottom of a lighted burner and hold a glass tube in the upper part of the yellow flame. Note the deposit. What is it? Where did it come from? Open the holes and move the tube up and down in the colorless Bunsen flame. What becomes of the deposit? Why?

c. Dip a glass tube a short distance into some powdered wood charcoal, place the end containing the charcoal in one of the holes at the bottom of the lighted burner, and blow gently two or three times into the other end. Describe and explain the result.

d. Open and close the holes of a lighted burner several times. Describe the result. Pinch the rubber tube to extinguish the flame, then light the gas at the holes. What change is produced in the flame? What is the object of the holes?

e. Lay a match across the top of the tube of a lighted Bunsen burner. When the match begins to burn, remove and extinguish it. Note where it is charred, and explain the result.

Press a piece of wire gauze down upon the flame. Describe and explain the appearance of the gauze (Fig. 78).

Stick a pin through a match near the head, and suspend it across the burner (Fig. 79). Turn the gas on full and light it. What is the effect on the match? What does the whole of **e** show about the structure of the lower part of the Bunsen flame? Verify your answer by **f**.

f. Hold one end of a glass tube (about 15 cm. or 6 in. long) in the Bunsen flame about 2 cm. (1 in.) from the top of the burner tube

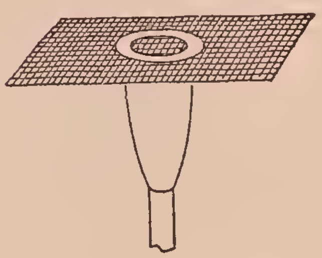


Fig. 78. — Studying the cones of a Bunsen flame

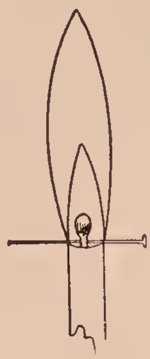


Fig. 79. — Studying the lower part of a Bunsen flame

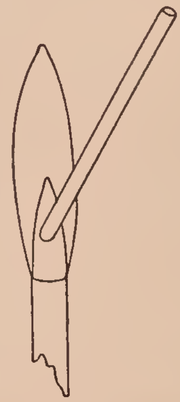


Fig. 80. — Studying the inner cone of a Bunsen flame

(Fig. 80). Hold a lighted match for an instant at the upper end of the tube; raise or lower the tube slightly (still keeping the end in the flame) and observe the result. What does the result show about the structure of the Bunsen flame? How does it verify **e**?

g. Find the hottest part of the flame, when a full current of gas is burning, by holding a copper wire in the flame (Fig. 2). Measure its distance, approximately, from the top of the burner tube.

h. Examine an imperfect Bunsen burner flame — one which shows the outlines of the inner part. What is the general shape of each main part? Draw a vertical and a cross section.

i. Using the same burner as in **h**, lower the flame gradually until

it strikes back. Now observe the place where the gas burns. Note the odor. Feel *cautiously* of the tube and describe the result.

Experiment 134 — Reduction and Oxidation with the Blowpipe

MATERIALS. — Charcoal, lead oxide, sodium carbonate, sodium sulphate, powdered wood charcoal, silver coin, zinc, lead, tin.
APPARATUS. — Blowpipe, blowpipe tube.

Slip the blowpipe tube (Fig. 81) into the burner tube. Light the gas and lower the flame until it is about 4 cm. (1.5 in.) high. Rest the tip of the blowpipe (Fig. 82) on the top of the blowpipe tube, placing the tip just within the flame. Put the other end of the blowpipe between the lips, puff out the cheeks, inhale through the nose, and exhale into the blowpipe, using the cheeks somewhat as bellows. Do not blow in puffs, but produce a continuous flow of air through the blowpipe (Fig. 83). The flame should be an inner blue cone surrounded by an outer and almost invisible cone (Fig. 84).

FIG. 81. — Blowpipe tube

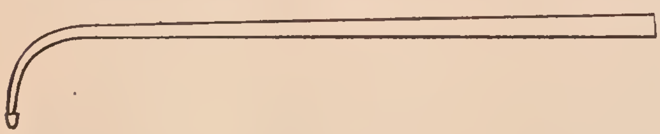


FIG. 82. — Blowpipe

A. **Reduction.** — **a.** Make a cavity in one end of the flat side of a piece of charcoal. Fill it with a mixture of equal parts of powdered sodium carbonate and lead oxide, and heat the mixture in the reducing flame (*B* in Fig. 84). In a short time bright, silvery globules should appear on the charcoal. Let the mass cool, and pick out the largest globules. Put one or two in a mortar, and strike with a pestle. Are they soft or hard? Malleable or brittle? How do the properties compare with those of metallic lead? What has become of the oxygen?

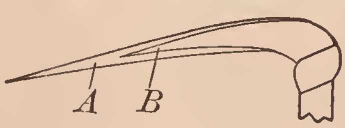


FIG. 84. — Blowpipe flame — *A* (oxidizing) and *B* (reducing). The flame is coming out of the upper end of the blowpipe tube

b. Grind together in a mortar a little sodium sulphate and powdered

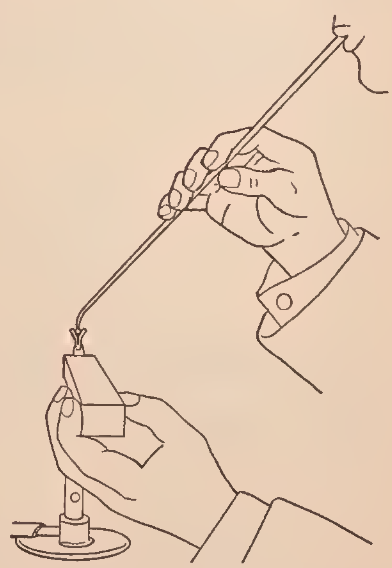


FIG. 83. — Using the blowpipe

wood charcoal, adding at intervals just enough water to hold the mass together. Heat some of this paste in the reducing flame as in **a**. Scrape the mass into a test tube, boil in a little water, and put a drop of the solution on a bright silver coin. If a dark brown stain is produced, it is evidence of the formation of silver sulphide. Repeat, if no such stain is produced. The silver sulphide is formed by the interaction of the silver and sodium sulphide. Explain how the experiment illustrates reduction.

B. **Oxidation.** — **a.** Heat a small piece of zinc on charcoal in the oxidizing flame (*A* in Fig. 84). Direct the flame across the zinc so that most of the product will form a coating on the charcoal. What is the product? Observe the color of the coating on the charcoal when both hot and cold. Record the result.

b. Heat a piece of lead as in **a**. Observe the color of the coatings (hot and cold). Record the result.

c. Optional. Heat a small piece of tin in the oxidizing flame. Observe and record as in **b**.

Optional Exercises. — 1. Name the products formed in **B**.

2. Sketch a flame showing the oxidizing and reducing parts.

Experiment 135 — Testing for Metals and Non-metals

Materials. — Compounds of zinc, lead, and tin, insoluble sulphates (*e.g.* of calcium, barium, lead), charcoal.

Obtain "unknowns" and apply (1) the blowpipe or the flame test for the metal, (2) the blowpipe test for an insoluble sulphate, and (3) if necessary other tests, *e.g.* for chloride, sulphate, carbonate, nitrate. State each result.

Give the name and formula of each compound.

OTHER CARBON COMPOUNDS

(Practical Chemistry, pp. 289–305, §§ 339–372)

Experiment 136 — Sucrose (Cane Sugar) and Dextrose

a. Proceed as in Exp. 114 **e**.

b. Proceed as in **a**, using dextrose instead of sucrose. Compare the results.

c. Add 10 cc. of Fehling's solution (see App. § 6, List G) to 5 cc. of dextrose solution, and heat to the boiling point. Note the result. The precipitate is cuprous oxide. Describe it.

d. Repeat **c**, using cane sugar solution instead of glucose. Do not boil the mixed solutions. State the result. Compare with **a**.

e. Apply Fehling's test for dextrose (and similar sugars) to cheap candy, maple sugar, molasses, table sirups, jelly, jam, etc. Prepare and use clear solutions. State each result.

Experiment 137 — Properties of Starch

MATERIALS. — Starch, Fehling's solution, iodine solution.

Prepare a starch mixture by boiling about 1 gm. of powdered starch for a few minutes in 50 cc. of water; stir or agitate the mixture during the boiling. Make three tests with the starch mixture.

(1) Pour half of it into an evaporating dish which stands on a gauze-covered ring, add 1 cc. of concentrated sulphuric acid, mix well, and boil for at least ten minutes; add water occasionally to replace that lost by evaporation. Meanwhile proceed with (2).

As soon as the mixture (in (1)) has been boiled at least ten minutes, take out a little, add sodium hydroxide solution to alkaline reaction and apply Fehling's test. Note the result. Continue the heating for ten or more minutes, and test again. State the final result.

(2) Dilute half of the rest of the original starch mixture with water and test it with Fehling's solution. Observe and state the final result. Compare with (1).

(3) Add a drop or two of very dilute iodine solution to the rest of the starch mixture. Observe the color. (This test for starch is delicate, and dilute mixtures should be used.)

Experiment 138 — Detection of Starch by Iodine

MATERIALS. — Dilute solution of iodine; potato, rice, bread, and substances enumerated in **b**.

a. Test potato, rice, and bread for starch by moistening each separately with water, and then adding a drop or two of very dilute iodine solution. State the result in each case.

b. Proceed as in **a**, using substances not positively known to contain starch, *e.g.* baking powder, leaves of different kinds of trees, roots of vegetables, popped corn, straw, and various kinds of food. State each result.

Experiment 139 — Properties of Ethyl Alcohol

MATERIALS. — Ethyl alcohol, camphor, shellac, rosin, iodine, ether, carbon disulphide, carbon tetrachloride.

Apparatus. — Tall jar, hydrometer for light liquids (as in Exp. 126).

a. Drop a little ethyl alcohol on a glass plate, and watch it evaporate. Does it evaporate more rapidly than water?

b. Weigh a measured quantity (about 25 cc.) of alcohol in a graduated cylinder and calculate its specific gravity. (See Exp. 114 **a.**)

c. Determine the specific gravity of alcohol with the hydrometer. State the result. (See Exps. 114 **a** and 126 **d.**)

d. Try the solvent power of alcohol by adding powdered substances to 5 cc. in separate test tubes, *e.g.* camphor, powdered shellac, rosin, or iodine. Describe each result. Add water to each solution. Describe and explain the result.

e. Proceed as in **d**, using liquids, *e.g.* water, ether (care!), carbon disulphide (care!), carbon tetrachloride. State each result.

f. Burn a little alcohol in a porcelain dish and observe the properties of the flame, *e.g.* color, heat. What are the products of combustion?

Experiment 140 — Tests for Ethyl Alcohol

a. Proceed as in Exp. 142 **a.**

b. To 5 cc. of ethyl alcohol add a crystal or two of iodine and just enough sodium hydroxide solution to dissolve and decolorize the iodine. Warm gently several minutes and then cool. Note the odor of the yellow product. It is iodoform and its formation is a test for alcohol.

Experiment 141 — Properties of Acetic Acid

Materials. — Acetic acid, magnesium ribbon.

a. Put 5 cc. of acetic acid in a test tube. Note the odor and taste (cautiously). Warm a little in a test tube, and smell (cautiously). Describe the odor. Is acetic acid volatile? Test with litmus paper, and describe the result.

b. Prepare, or obtain, a solution of 5 cc. of acetic acid in 15 cc. of water and a similar solution of sulphuric acid and water. Drop a short piece of magnesium ribbon into each and note the result. In which acid is the action faster? Is acetic acid a weak or a strong acid?

Experiment 142 — Test for Acetic Acid and Acetates

Materials. — Concentrated sulphuric acid, acetic acid, ethyl alcohol, sodium acetate solution.

a. Cautiously add a few drops of concentrated sulphuric acid to a mixture of 5 cc. each of acetic acid and ethyl alcohol. Shake the mixture and warm gently. Note the odor. The pleasant, fruitlike odor is due to ethyl acetate.

b. Proceed as in **a**, using sodium acetate solution.

Experiment 143 — Properties of Vinegar

MATERIALS. — Vinegar, solutions for **a**, sodium cobaltinitrite solution (for **b** (2)).

a. Show that vinegar contains acetic acid.

b. Evaporate 15 cc. of vinegar to dryness on a water bath and note the residue. Stand the dish on a gauze-covered ring and heat gently. Note the ash.

Test the ash for (1) a carbonate and (2) potassium. (1) Add dilute hydrochloric acid to the residue, and note the effervescence. Warm gently to expel the gas, and filter. (2) To the filtrate from (1) add 5 to 10 cc. of sodium cobaltinitrite solution. The yellow precipitate is a test for potassium (compare Exp. 182 **b**).

Experiment 144 — Preparation of Soap

MATERIALS. — Sodium hydroxide, lard, salt.

a. Dissolve 10 gm. of sodium hydroxide in 75 cc. of water, add 30 gm. of lard, and boil the mixture in a porcelain (or metal) dish for an hour or more; add water occasionally to replace that lost by evaporation. Then add 20 gm. of fine salt in small portions. Stir constantly during the addition of the salt. Let the mass cool, and remove the cake of soap.

b. Optional for Class or Teacher. Prepare soap by the method given on a can of commercial "lye."

Experiment 145 — Properties of Soap

MATERIALS. — Soap, sulphuric acid; calcium sulphate, magnesium sulphate, and acid calcium carbonate solutions for **e**.

a. Leave soap shavings exposed to the air for several days. What does the result show about the presence of water in the soap?

b. Test the soap made in Exp. 144 with wet litmus paper. State the result. Test other samples and compare.

Put a few drops of phenol-phthalein solution (alcoholic) on samples of dry soap. State the result. This is a test for "free alkali."

c. Prepare 25 cc. of a solution of the soap made in Exp. 144

Warm it and examine the surface for fat (film or globules). Is fat detected? Why?

d. Add 20 cc. of dilute sulphuric acid to 10 cc. of soap solution. Note the result. The precipitate is a mixture of palmitic and stearic acids. Describe it.

e. Optional. See Exp. 191.

Experiment 146 — Carbon Tetrachloride

MATERIALS. — Carbon tetrachloride, joss stick.
APPARATUS. — Iron crucible, pyrene fire extinguisher (for **b**).

a. Heat the bottom of an iron crucible (or metal pan), drop in some carbon tetrachloride, and hold a blazing joss stick or a piece of burning paper in the vapor. Describe the result.

b. Optional. Examine and describe a pyrene fire extinguisher.

FOOD AND NUTRITION

(Practical Chemistry, pp. 307–314, §§ 373–382)

Experiment 147 — Testing for Nutrients in Food

MATERIALS. — Foods; Molisch's, iodine, Fehling's and sodium hydroxide solutions; gasolene, concentrated nitric acid, soda lime (for **d** (1)), very dilute copper sulphate solution.

Apply tests for carbohydrate, fat, and protein to various foods from the Table in §§ **377** and **381** of the author's *Practical Chemistry*.

a. Carbohydrate. — Apply the Molisch test. To 5 cc. of a clear dilute solution of the carbohydrate (or food), add 2 cc. of Molisch's solution, and shake. Incline the test tube and carefully pour down the inside 5 cc. of concentrated sulphuric acid so that two layers will form. At the contact zone a red-violet color will appear slowly. State the result.

b. Carbohydrate. — Test for starch (Iodine Test — Exps. 137 **b** (3), 138) and sugar (Fehling's Test — Exp. 136 **c**). State each result.

c. Fat. — Grind the sample with gasolene (care!) in a mortar, pour off the gasolene into an evaporating dish (filter, if not clear), let it evaporate, and examine the residue. Rub a little between the fingers. Burn a little on the end of a glass rod. State each result.

d. Protein. — (NOTE. — Use two or more of these tests.) (1) Proceed as in Exp. 54 **a**.

(2) Grind the sample with 20 cc. of water in a mortar, pour off the water (filter, if not clear). To about 5 cc. of the dilute extract add an equal volume of sodium hydroxide solution and shake well. Then add drop by drop a very dilute copper sulphate solution. A violet color is produced.

(3) To 5 cc. of the extract from (2) add an equal volume of concentrated nitric acid. Heat gently until a yellow precipitate or a yellow solution is obtained. Cool in running water and add an excess of sodium hydroxide solution. An orange color is produced.

(4) To 5 cc. of the extract from (2) add concentrated nitric acid slowly, pouring the acid down the inside of the tube so the two solutions will not mix. A white cloudy precipitate is formed at the surface of the two liquids.

Experiment 148 — Testing for Water in Food

a. Proceed as in Exp. 25 **a**, using samples from the Table in § **377** of the author's *Practical Chemistry*. State each result.

Experiment 149 — Testing for Mineral Matter in Food

Heat a sample of the food in an evaporating dish or crucible, or on a piece of porcelain, in the hood, until the residue is white or gray. This is the mineral matter. If the food, *e.g.* beans, cheese, or peanuts, contains considerable mineral matter, tests may be applied to the residue. See Exp. 153 **e** for phosphorus, Exp. 153 **h** for calcium, and Exps. 143 **b** (2) and 182 **b** for potassium.

Experiment 150 — Testing Bread

a, b, c. Carbohydrate, Fat, Protein. — Proceed as in Exp. 147 **b**, **c**, **d**, using samples of bread. State each result.

d. Water. — (1) Proceed as in Exp. 25 **a**, using bread.

(2) Optional. Weigh a porcelain dish, put in a piece of fresh bread about $5 \times 5 \times 1$ cm., and weigh again. Heat the dish gently in an oven (not above 105° C.) for several hours or let it stand for several days in a desiccator containing concentrated sulphuric acid. Weigh again. What weight of water was lost? What per cent?

e. Mineral matter. — Proceed as in Exp. 149, using bread. State the result.

Experiment 151 — Testing Butter and Substitutes

a. Put a small lump of butter in an evaporating dish, heat gently with a small flame, and note the result.

b. Proceed as in **a**, using separately samples of butter substitutes Note the result and compare with **a**.

Experiment 152 — Testing Milk

MATERIALS. — Milk, acetic acid, sodium hydroxide, dilute copper sulphate solution, junket tablet, gasolene; ammonium oxalate and ammonium molybdate solutions (for **d**).

APPARATUS. — Babcock apparatus — Fig. 85 — (for **c** (2)).

a. Water and solids. — Clean and dry an evaporating dish. Weigh it together with a glass rod (about 8 cm. long) on the balance (or good scales). Record the weight. Pour about 25 cc. of well-mixed milk into the dish and weigh again. Record the weight. The difference between these weights is the weight of the milk. Stand the dish on a water bath and evaporate to dryness, stirring occasionally to hasten evaporation. Meanwhile do **b**, etc.

When the residue is dry, let the dish cool, wipe it dry, and weigh. The decrease in weight is due to the loss of water. Save the residue for **c**. From the weight of the milk taken and the weight of the residue, calculate the per cent of (1) water and (2) solids in the milk. (Milk contains about 88 per cent of water. Unless the residue is dry, the result will be only approximate.)

b. Protein. — (1) Boil about 50 cc. of milk in an evaporating (or other) dish. Note the formation of a scum. Remove this scum with a glass rod to a test tube, collecting several portions, and test it as in Exp. 147 **d** (2) (or another test).

(2) Add 3 or 4 drops of acetic acid to 10 cc. of milk in a test tube, and shake. The curdy precipitate is casein. Filter, and test the solid for protein as in (1). Test the filtrate for albumin (a kind of protein) by boiling; the heat coagulates the albumin into white flakes.

(3) Add a small fragment of a junket tablet to 10 cc. of warm milk. Separate and test as in (2).

c. Fat. — (1) To the residue from **a** add 10 cc. of gasolene (care!) and mix well. Pour off the gasolene into a beaker or a dish and let it evaporate. Save the dish and contents for **d**. Examine the solid from the gasolene extract. Rub a little between the fingers, and burn a little on the end of a glass rod. Is fat detected?

(2) Optional or Demonstration Experiment. The Babcock test. Shake the sample of milk, measure 17.6 cc. into the special milk graduate (Fig. 85 *A*), and pour it carefully into the test bottle (Fig. 85 *B*). If a pipette (Fig. 85 *C*), instead of a graduate, is used, fill the pipette

as follows: Put the lower end well into the milk and the other end into the mouth; suck out the air until the milk rises above the 17.6 cc. mark on the stem, remove the pipette from the mouth and quickly

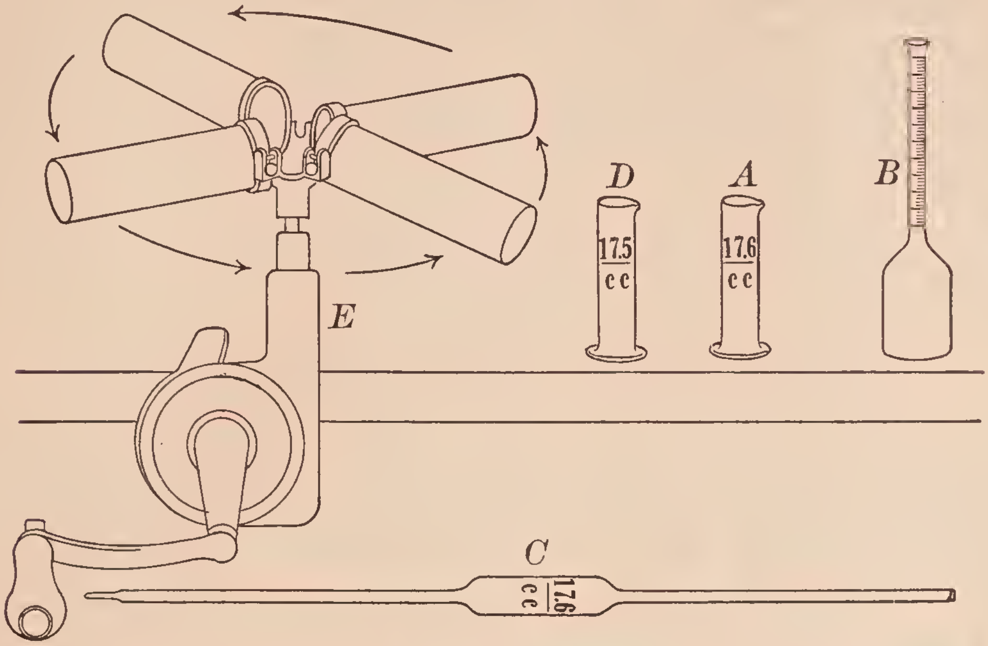


FIG. 85.— Babcock apparatus for testing milk — *A*, milk graduate; *B*, test bottle; *C*, pipette; *D*, acid graduate; *E*, centrifugal machine

cover the end with the finger; move the finger a little and let milk run out slowly until it reaches the 17.6 cc. mark.

Next measure 17.5 cc. of concentrated sulphuric acid into the special acid graduate (Fig. 85 *D*). Pour the acid carefully in small portions into the test bottle. Shake carefully after each addition. This operation dissolves the curd (*i.e.* the casein) and facilitates the separation of the fat.

Label the bottle and put it in the centrifugal machine (Fig. 85 *E*) together with three other bottles filled similarly with milk and acid, or with water (if only one test is being made). Whirl the machine rapidly and uniformly for five minutes; the melted fat will rise and collect on the surface of the liquid. Add enough hot water to fill the larger portion of the bottle, and whirl for two more minutes. Then add hot water carefully until the water is just below the top graduation on the stem (*not* above the graduation), and whirl again for two minutes.

Remove the bottle from the machine and stand it in a dish containing water at 60° C. In a minute or two, remove the bottle and read the volume of fat, taking care to read from the *top* of the *upper* meniscus (curved surface of the fat) to the *bottom* of the *lower* meniscus. The difference between the two readings is the per cent of fat

in the milk. Report the per cent to the Teacher before throwing away the contents of the bottle. If the result is accepted, pour the liquid into a waste jar and wash the bottle clean with hot water.

d. **Mineral matter.** — If the dish and contents (from which the fat was extracted) from **c** (1) is available, use it. If not, evaporate 10 cc. of milk to dryness and use the residue. Heat the dish and contents in the hood until the residue is white or gray. Dissolve this mineral matter in water and test portions for calcium and a phosphate (as in Exp. 153 **h**, **e**). State the results. What component of milk contains most of the mineral matter?

Experiment 153 — Testing Baking Powders

MATERIALS. — Baking powder (tartrate, phosphate, alum), barium hydroxide, vinegar, sour milk, lemon juice, solutions of iodine, silver nitrate, ammonium chloride, sodium hydroxide, and ammonium oxalate.

NOTE. — Different varieties of baking powder may be tested by individuals or sections, and the results compared.

a. **Carbonates.** — (1) Put a little baking powder in a test tube, add a few drops of dilute hydrochloric acid, and test the escaping gas with a tube which has been dipped into barium hydroxide solution. State the result.

(2) Put 2 gm. of baking powder in a test tube, add 15 to 20 cc. of water, and shake well. Let the action continue a short time, and then test the solution as in (1). State the result.

(3) Add sour substances, *e.g.* vinegar, sour milk, lemon juice, separately to a little baking powder, and state the result.

b. **Starch.** — Apply the iodine test for starch to a little baking powder mixed with water. See Exp. 137 (3). State the result.

c. **Tartrates.** — Prepare a cold solution of baking powder by shaking about 10 gm. of the substance with 50 cc. of water and stirring until all the gas is liberated. Filter, if not clear, and use the clear solution in this and succeeding experiments. (1) Clean a test tube by boiling sodium hydroxide solution in it and then washing thoroughly with water. Put 10 cc. of silver nitrate solution in the cleaned test tube, and add ammonium hydroxide slowly until the precipitate at first formed redissolves, taking care to mix the solutions. Add 10 cc. of the baking powder solution and warm gently. Tartrates, if present, will reduce the silver compound to silver, which will coat the inside of the test tube. (2) Put about 5 cc. of the solution from **c** in an evaporating dish, add a few drops of concentrated sulphuric

acid, and heat gently. Tartrates, if present, will char and smell like burnt sugar.

d. Sulphates. — To 5 cc. of the baking powder solution (prepared in **c**) add dilute hydrochloric acid to acid reaction and boil; then test with barium chloride solution. State the result.

e. Phosphates. — Warm 5 cc. of the baking powder solution, acidify with concentrated nitric acid, and add 5 cc. of ammonium molybdate solution. A yellow precipitate indicates phosphates. State the result.

f. Ammonium salts. — Boil 5 cc. of the baking powder solution with an equal volume of sodium hydroxide solution. The presence of ammonium salts is shown by the liberation of ammonia gas, which can be detected by its odor. State the result.

g. Aluminium salts. — Boil 5 cc. of the baking powder solution with 1 or 2 cc. of dilute hydrochloric acid, filter if not clear, and add 10 cc. or more each of ammonium chloride and ammonium hydroxide to the filtrate. A whitish flocculent precipitate (aluminium hydroxide) indicates aluminium salts. State the result.

h. Calcium salts. — Boil 10 cc. of the baking powder solution with dilute hydrochloric acid (to remove the carbon dioxide), add ammonium hydroxide to alkaline reaction, filter, if not clear and then add ammonium oxalate solution. Calcium compounds produce a white precipitate (calcium oxalate).

SILICON

(Practical Chemistry, pp. 316–327, §§ 383–395)

Experiment 154 — Preparation of Sodium Silicate

MATERIALS. — Powdered silicon dioxide, sodium carbonate.

APPARATUS. — Iron crucible.

Mix thoroughly about 0.5 gm. of fine sand and 4 gm. of sodium carbonate and put the mixture in an iron crucible. Stand the crucible on a triangle (or in a small ring) and heat gently until the mass ceases to bubble. Then heat intensely for ten or fifteen minutes. Allow the crucible to cool somewhat, add 25 cc. of hot water, and heat until the water boils. When cold, filter, and evaporate the filtrate to about half its volume. This solution contains sodium silicate. Save it for Exp. 155.

State the chemical changes by which silicon dioxide is transformed into sodium silicate.

Experiment 155 — Silicic Acid

MATERIALS. — Sodium silicate solution, hydrochloric acid.

a. To the solution from Exp. 154 add dilute hydrochloric acid drop by drop, shaking constantly until a precipitate is formed. The precipitate is silicic acid. Describe it.

b. Optional. Put 10 cc. of commercial sodium silicate solution in an evaporating dish, and add 10 to 15 cc. of dilute hydrochloric acid, stirring constantly. The jellylike precipitate is silicic acid. Rub some between the fingers and state the result.

Stand the dish on a gauze-covered ring attached to an iron stand and evaporate the solution slowly to dryness in the hood. As the mass thickens, stir it with a glass rod. Toward the end add more hydrochloric acid and evaporate to complete dryness. Then heat intensely for five minutes. When the dish is cool, add about 50 cc. of water, stir well, and filter; wash the residue with water once or twice, dry it, remove as much as possible from the paper, and heat it carefully in an evaporating dish for about five minutes. Rub some between the fingers or across a glass plate. State the result. Collect some within the loop of a test wire and heat it intensely in the flame for several minutes. State the result. What is this residue?

State the chemical changes that occur in changing sodium silicate into the final residue.

Experiment 156 — Testing for Silicon

MATERIALS. — Powdered calcium fluoride, sand, substances for **b**.
APPARATUS. — Lead dish, test wire.

a. Put a little sand and calcium fluoride in a lead dish (see Fig. 86, Exp. 158), add enough concentrated sulphuric acid to moisten the mixture, and stir with a match. Dip the looped end of a test wire into water, inclose a film of water within the loop, and hold the loop at several points near the mixture in the dish until the water (in the loop) becomes white. If no change occurs, stir the mixture and hold the loop over the place where there is evidence of chemical action. State the result. What is the white substance in the loop? State in words the chemical changes that led to the formation of the white substance in the loop. Write the equations.

b. Apply the test for silicon to several of these substances (omitting the sand): Powdered calcium fluoride, infusorial earth, pumice (powder), scouring soap, glass (small fragments), carborundum

(powder), ash from coal, electro-silicon, glass wool, mineral wool, soil. State the result in each case.

Experiment 157 — Carborundum

Examine and describe carborundum. Try its hardness on glass, wood, and other solids, and state the result. Wind a test wire around a small lump, heat intensely for ten minutes, and state the result.

FLUORINE — BROMINE — IODINE

(Practical Chemistry, pp. 337–344, §§ 404–418)

Experiment 158 — Etching with Hydrogen Fluoride

MATERIALS. — Paraffin, powdered calcium fluoride.
APPARATUS. — Lead dish, glass plate (see Fig. 86).

Caution. — Do not inhale hydrogen fluoride.

Warm a glass plate about 10 cm. (4 in.) square by dipping it into hot water or by moving it slowly above a flame. Coat one surface uniformly with a thin layer of paraffin wax. Scratch letters, figures, or a diagram through the wax with a pin or pointed glass rod. The wax should be removed through to the glass, and the lines should be rather coarse.

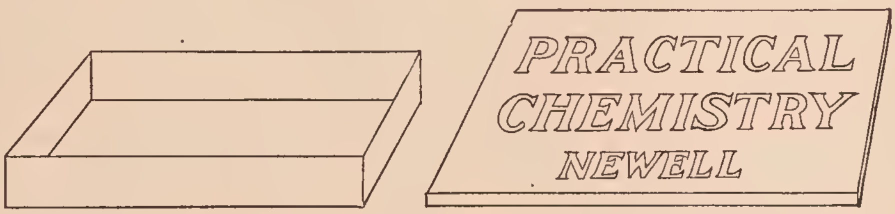


FIG. 86. — Etching with hydrogen fluoride — lead dish (left), etched glass plate (right)

Put about 5 gm. of powdered calcium fluoride in a lead dish and add just enough concentrated sulphuric acid to form a thin paste (Fig. 86). Stir the mixture with a match. Place the glass, wax side down, upon the lead dish and let the whole stand in the hood for several hours.

Remove the glass and scrape off the wax with a knife. The last portions can be removed by rubbing with a cloth moistened with hot water. Do not attempt to melt off the wax over the flame. Examine and describe the glass (Fig. 86).

State in words the essential chemical changes in this experiment. Write the equations.

NOTE. — The lead dish should be cleaned in the hood by scraping the contents carefully into a waste jar and washing the whole dish with water.

Experiment 159 — Preparation and Properties of Bromine

MATERIALS. — Potassium bromide, manganese dioxide, sulphuric acid.

APPARATUS. — As in Fig. 87 for **b**; bottle fitted with a cork. The large test tube has a one-hole rubber stopper to which is fitted the bent glass tube; the total length of the glass tube is about 30 cm. (12 in.).

Caution. — Bromine is a corrosive liquid, which readily forms a suffocating vapor. Perform all experiments with bromine in the hood.

a. Short method. — Put a little powdered potassium bromide and twice the bulk of manganese dioxide in a test tube. Add 5 cc. of dilute sulphuric acid and mix well. Attach a test tube holder and heat gently. Bromine vapor is evolved. Note the color and *very cautiously* the odor. If any of the vapor condenses on the inside of the test tube, describe the liquid. (See Note below.)

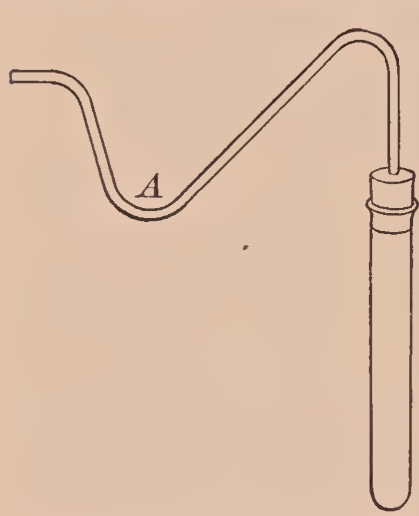


FIG. 87. — Apparatus for preparing bromine

b. Long method. — Put about 3 gm. of potassium bromide in a large test tube, and add 5 gm. of manganese dioxide; shake well, and add 10 cc. of dilute sulphuric acid. Insert the stopper and its tube (Fig. 87), attach the test tube holder, and warm gently. Bromine vapor soon appears in the test tube and, if the heat is sufficient, some vapor will escape from the delivery tube. Note the color and *very cautiously* the odor. Is the vapor heavier or lighter than air?

Heat to such a temperature that the vapor will condense and collect in the bend *A* of the delivery tube. When no further boiling produces bromine vapor in the test tube, transfer the bromine from the delivery tube into a bottle half full of water by holding the end of the delivery tube over the mouth of the bottle and heating the test tube slightly; the expanding gases will force the liquid bromine out of the bend into the bottle.

Observe and record the physical properties of this bromine, especially the color, solubility in water, specific gravity, volatility, and physical state. As soon as these observations have been made, cork the bottle tightly and shake it vigorously. Observe the result, and draw a conclusion about the solubility of bromine in water.

NOTE. — Wash the delivery tube free from bromine, taking care to get none on the hands. Throw the contents of the test tube into a waste jar in the hood and wash the tube.

Experiment 160 — Tests for Bromides

Materials. — Potassium bromide, silver nitrate solution, carbon tetrachloride.

a. Add a little concentrated sulphuric acid to a little potassium bromide in a test tube; warm slightly, if the action is not marked. Observe the result, especially the color of the liquid or of the vapor just above the liquid. What element does the color suggest?

b. Dissolve a crystal of potassium bromide in a test tube half full of water, add a little silver nitrate solution, and shake. Observe the properties of the precipitate, especially the color and texture. Determine the solubility by warming a little of the precipitate in ammonium hydroxide. State the result. Compare silver bromide and silver chloride (Exp. 65 **III b**).

c. To a solution of a bromide, add a little chlorine water and a few drops of carbon tetrachloride, and shake. The carbon tetrachloride will be colored yellow or brown by the liberated bromine.

Experiment 161 — Preparation and Properties of Iodine

Materials. — Potassium iodide, manganese dioxide, concentrated sulphuric acid, cotton, alcohol, carbon tetrachloride, potassium iodide solution.
Apparatus. — As in Fig. 88 (for **b**).

Do **a** or **b**. **a. Short method.** — Proceed as in Experiment 159 **a**, using potassium iodide in place of potassium bromide. Note the color and (cautiously) the odor of the vapor, and the color of the sublimed iodine.

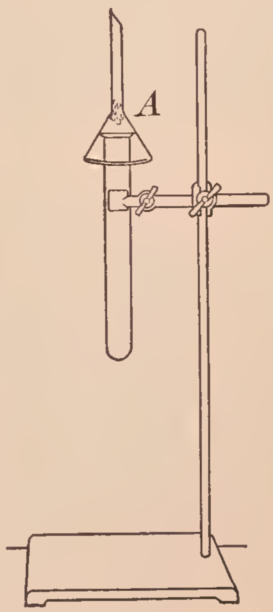


Fig. 88. — Apparatus for preparing iodine

b. Long method. — Grind together in a mortar about 3 gm. of potassium iodide and 5 gm. of manganese dioxide. Put the mixture in a test tube, add about 3 cc. of water, 5 cc. of concentrated sulphuric acid, and mix well. Clamp the test tube vertically to an iron stand (Fig. 88). Close up the inner end (*A* in Fig. 88) of the stem of the funnel with a small plug of cotton. Hold, or place, the funnel over the mouth of the test tube, and heat the test tube gently. The vapor of the liberated iodine will fill the test tube, and crystals will form in the upper part of the test tube and in the funnel. Continue to heat until enough iodine for several experiments collects in the funnel. Scrape the crystals into a dish.

Observe and record the color of the solid and of the vapor, and the odor (cautiously).

Determine the volatility by putting a small piece in a bottle and exposing to the sunlight.

Heat a crystal in a dry test tube, and invert the test tube when it is full of vapor. What does the result show about the density of iodine vapor?

Touch a crystal with the finger. What color is the stain?

Try the solubility separately in water, alcohol, carbon tetrachloride, and potassium iodide solution. What do these results show about the solubility of iodine?

NOTE. — If crystals are left, use them in the next experiment. Preserve the iodine in a stoppered bottle, if not used at once.

Experiment 162 — Tests for Free Iodine

MATERIALS. — Very dilute iodine solution, potassium iodide, carbon tetrachloride, cold starch mixture.

a. Add a few drops of carbon tetrachloride to a very dilute iodine solution. Shake well, and observe the color of the carbon tetrachloride.

b. Add 5 cc. of a cold starch mixture to a test tube nearly full of water, and then add a few drops of dilute iodine solution. Note the color. Pour about 5 cc. of the liquid into a test tube nearly full of water and shake. Note the color.

Experiment 163 — Tests for Iodides

MATERIALS. — Potassium iodide, chlorine water, starch, carbon tetrachloride, silver nitrate solution.

a. Add a few drops of carbon tetrachloride to a very dilute solution of potassium iodide. Then add several drops of chlorine water, and shake well. Note the color.

b. Add 5 cc. of cold starch solution to 10 cc. of a very dilute solution of potassium iodide. Add a few drops of chlorine water, and shake well. Observe and explain the result.

c. To 10 cc. of potassium iodide solution, add a little silver nitrate solution, and shake. Observe the properties of the precipitate, especially the color and texture. Test the solubility of a little of the precipitate in ammonium hydroxide, and state the result. Compare silver iodide with silver chloride and silver bromide (see Exps. 65 **III b**, 160 **b**).

Experiment 164 — Halogen Acids

Proceed as in Exp. 64 **a**, **b**, **d** (omit **c**), using (1) potassium bromide and (2) potassium iodide in separate test tubes.

Answer: 1. Which of the three halogen acids is the most stable? Least stable?

2. In what ways are these acids alike? Different?

PHOSPHATES — ARSENIC — ANTIMONY — BISMUTH

(Practical Chemistry, pp. 346–358, §§ 419–442)

Experiment 165 — Tests for Orthophosphoric Acid and Orthophosphates

MATERIALS. — Solutions of disodium phosphate, silver nitrate, ammonium molybdate, ammonium chloride, magnesium sulphate, and orthophosphoric acid; bone ash, fertilizer.

a. To 5 cc. of disodium phosphate solution add a little silver nitrate solution. Observe and describe the result. What is the name and formula of the precipitate?

b. To 5 cc. of disodium phosphate solution add 1 or 2 cc. of dilute nitric acid, and an equal volume of ammonium molybdate solution. Observe and describe the result. Warm, if no precipitate appears. The precipitate is ammonium-phospho-molybdate ($(NH_4)_3PO_4 \cdot 12MoO_3$, approximately).

Apply this test to a dilute solution of orthophosphoric acid (instead of disodium phosphate), and state the result.

c. To magnesium sulphate solution add successively solutions of ammonium chloride, ammonium hydroxide, and disodium phosphate. Observe and describe the result. The precipitate is ammonium magnesium phosphate.

d. Shake a little bone ash with warm dilute nitric acid, filter, and apply the ammonium molybdate test to the filtrate. State the result.

Experiment 166 — Preparation of Phosphate Fertilizer

MATERIALS. — Powdered phosphate rock, concentrated sulphuric acid, ammonium molybdate solution.

Put about 10 gm. of powdered phosphate rock in an evaporating dish, add 5 cc. of water, 5 cc. of concentrated sulphuric acid, and mix well. Heat gently about ten minutes, stirring frequently. Add

10 to 15 cc. of water, stir, let the mixture settle, and filter. Test the filtrate for a phosphate. State the result.

Experiment 167 — Test for Arsenic

See Exp. 111 d. Write the equation.

Experiment 168 — Test for Antimony

See Exp. 111 e. Write the equation.

Experiment 169 — Test for Bismuth

Add considerable water to 10 cc. of bismuth trichloride solution. The precipitate is bismuth oxychloride. Describe it. What is its formula?

Experiment 170 — Fusible Alloys

a. Slip a thin piece of fusible alloy into a test tube half full of water, hold a thermometer in the water, heat the water gradually, and note the temperature at which the alloy melts. State the result.

b. Optional. Heat a fusible link or a sprinkler head in water and note the temperature at which the alloy melts. State the result.

SODIUM AND POTASSIUM

(Practical Chemistry, pp. 360–374, §§ 443–469)

Experiment 171 — Properties of Sodium

Caution. — See Exp. 21.

a. Examine a small piece of sodium, and observe its most obvious physical properties, *e.g.* color, luster, whether hard or soft.

b. Perform, recall, or repeat (if necessary) the experiment on the Interaction of Sodium and Water (Exp. 21).

c. Fill a dish nearly full of water. Put a piece of sodium on a piece of filter paper (a little smaller than the dish), lay the paper upon the water, and stand back and observe the result. Wait for the slight explosion which usually occurs soon after the action stops. Describe all you have seen. What burned? To what is the vivid color of the flame probably due?

Experiment 172 — Tests for Sodium

Materials. — Sodium compounds, solutions of potassium hydroxide and tartar emetic.

a. Apply the flame test to several sodium compounds, using a clean test wire in each case (Fig. 89, left). State each result.

b. Make a solution of a sodium compound slightly alkaline with potassium hydroxide solution, and to 10 cc. add a little freshly prepared tartar emetic solution. The white precipitate is acid sodium pyroantimonate ($H_2Na_2Sb_2O_7$).

Experiment 173 — Properties of Sodium Chloride

MATERIALS. — Sodium chloride (several varieties).

a. Prepare about 50 cc. of a nearly saturated sodium chloride solution, and proceed with the crystallization as in Exp. 40. Examine and describe the best crystals.

b. Heat a few crystals of sodium chloride in a test tube. State and explain the result.

c. Put a little sodium chloride (*e.g.* table salt) in a test tube, and cork the test tube tightly. Put some of the same sample of salt in an open dish. Place both where they will not be disturbed for a day or two, and then compare the two specimens. State and explain the result.

Experiment 174 — Sodium Carbonate — LeBlanc Process

MATERIALS. — Sodium sulphate, calcium carbonate, wood charcoal, calcium hydroxide solution.
APPARATUS. — Iron crucible.

Mix and grind together in a mortar 6 gm. of sodium sulphate, 4 gm. of powdered calcium carbonate, and 1 gm. of powdered wood charcoal. Fuse the whole mixture in an iron crucible or a portion on a platinum foil. When cool, heat with a little water and filter.

Apply the flame test for sodium to a little of the filtrate and state the result. Divide the filtrate into two parts. To (1) add 5 cc. of dilute hydrochloric acid and to (2) add 5 cc. of calcium hydroxide solution. Observe and explain each result.

Experiment 175 — Hydrolysis of Sodium Carbonate

Test a solution of sodium carbonate with litmus paper (both kinds), and state the result. Interpret by the ionization theory.

Experiment 176 — Sodium Bicarbonate

MATERIALS. — Ammonium carbonate, ammonium hydroxide, sodium chloride.
APPARATUS. — Carbon dioxide generator (see Fig. 68).

I. Preparation. — Put 8 gm. of powdered ammonium carbonate and 75 cc. of ammonium hydroxide into a bottle; add about 35 gm. of fine sodium chloride, cork the bottle, and shake the mixture vigorously until most of the solid has dissolved. Pour off the clear solution into the bottle *C*.

Construct a carbon dioxide generator (see Exp. 120) like that shown in Fig. 68. Put about 20 gm. of marble in the generator bottle *A*, introduce dilute hydrochloric acid as usual, and pass carbon dioxide (free from hydrochloric acid) slowly through the solution in the bottle *C* from thirty to forty-five minutes (or less, if a precipitate forms). Then remove the generator, cork the bottle *C*, and let it stand an hour or more to allow the sodium bicarbonate to settle out of the solution. Filter, and wash quickly with a very little cold water. Dry the precipitate between filter paper. (NOTE. — If only a little of the precipitate is formed, use sodium bicarbonate from the laboratory bottle for **II.**)

II. Properties. — **a.** Subject small portions of the precipitate to the flame test for sodium and the usual test for a carbonate. State the result.

b. Put a little on moist litmus paper (both colors). Observe and explain the result.

c. Heat a little in a test tube inclined so that the open end is the lower. Observe the result. What is the visible product? Apply the usual test for carbon dioxide to the gas in the test tube; state the result. Continue to heat until there is no further evidence of change. Determine what the final residue is by applying to it tests for sodium, a bicarbonate as in **a** and **b**, and sodium carbonate (*e.g.* litmus test). State the result.

Experiment 177 — Properties of Sodium Hydroxide

a. Perform, recall, or repeat (if necessary) experiments with sodium hydroxide which show the effect of (1) exposing it to the air, (2) adding acid to it, (3) dissolving it in water, (4) heating its solution with aluminium.

b. Heat a small piece of sodium hydroxide on a piece of porcelain, and describe the result.

c. Expose a little pulverized sodium hydroxide in a dish to the air for a day or more. Describe the final product. Test it for a carbonate, and state the result.

d. Fuse a small quantity of sodium hydroxide on a piece of porcelain, add a part of a match stick or a small piece of paper, and continue the fusion. State the effect on the wood or paper.

Experiment 178 — Sodium Hydroxide by Electrolysis

(Demonstration Experiment)

Proceed as in Exp. 61. See Fig. 43.

Experiment 179 — Properties of Borax

a. Let a piece of red litmus paper stand in borax solution for about ten minutes. Observe and explain the result.

b. Test borax for water of crystallization, and state the result. Expose borax crystals to the air for an hour and state the result.

c. Apply the flame test to a little borax on the end of a clean test wire. What element is contained in borax according to this test?

d. Dissolve a little borax in water, add 5 cc. of ethyl alcohol, 5 cc. of concentrated sulphuric acid, and mix well. Test for borax by dipping a clean test wire into the solution and holding it in the outer part of the Bunsen flame. Note the color of the flame.

Experiment 180 — Tests with Borax Beads

MATERIALS. — Powdered borax, cobalt nitrate, copper sulphate, and manganese sulphate solutions.

Heat the looped end of a clean test wire and dip it into powdered borax. Heat the adhering borax in the flame, rotating the wire slowly, until no further change is apparent; continue to dip it into the borax and heat in the flame until a small bead is formed.

a. Cobalt Compounds. — Moisten a borax bead with cobalt nitrate solution. Heat the bead in the oxidizing part of the Bunsen flame

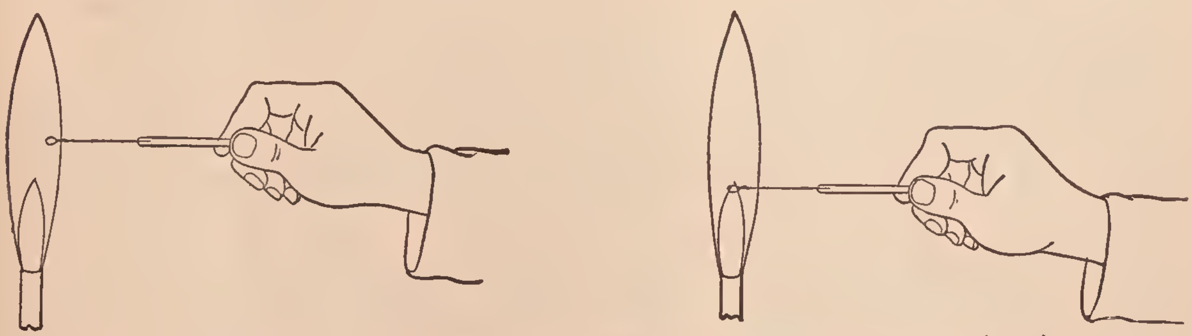


FIG. 89. — Heating a borax bead in the oxidizing flame (left) and the reducing flame (right)

(Fig. 89 left); rotate the bead while heating it. Observe the color of the cold bead. If it is black, melt a little more borax into the bead; if faintly colored, moisten again with the cobalt solution. The color is readily detected by looking at the bead against a white object in a strong light, or by examining it with a lens.

When the color has been definitely determined, heat the bead in the reducing flame (Fig. 89 right). Compare the color of the cold bead with the previous observation. State the result.

NOTE. — The bead may be removed from the wire by dipping it, while hot, into water and then rubbing or scraping it from the wire.

b. Copper Compounds. — Proceed as in **a** with another bead and copper sulphate solution. Compare the colors of the cold beads, and state the result.

c. Manganese Compounds. — Proceed as in **a** with another bead and manganese sulphate solution. Compare the colors of the cold beads, and state the result.

Experiment 181 — Properties of Potassium

(Demonstration Experiment)

Caution. — Observe the same precaution as in using sodium. (See Exp. 21.)

a. Examine a small piece of freshly cut potassium, and observe its most obvious physical properties.

b. Proceed as in Exp. 32 **b**. What compound of potassium is in solution? Write the equation.

Experiment 182 — Tests for Potassium

MATERIALS. — Potassium compounds, sodium cobaltinitrite solution.

a. Apply the flame test to several potassium compounds, using a clean test wire in each case. State the result.

b. Add 5 cc. of sodium cobaltinitrite solution to 10 cc. of a moderately concentrated solution of a potassium compound, and shake well. The yellow precipitate is potassium cobaltinitrite ($K_3Co(NO_2)_6$).

Experiment 183 — Potassium Nitrate

MATERIALS. — Sodium nitrate, potassium chloride, charcoal.

I. Preparation. — Dissolve about 15 gm. of potassium chloride in about 40 cc. of water, warming if necessary. Add about 17 gm. of sodium nitrate, and stir well. Boil several minutes, or until a white solid separates. Let the solid settle somewhat, then pour off the liquid into an evaporating dish and let it stand till crystals separate. Pour off the liquid from the crystals. Dissolve the crystals

in a small volume of hot water and let the solid crystallize out again. Drain off the water and dry the crystals between filter paper.

II. **Properties.** — **a.** Prepare a solution of the final crystals and test portions for (1) potassium and (2) a nitrate. State the result.

b. Test the solution also for (1) sodium and (2) a chloride. State the result. Explain it.

c. Proceed as in Exp. 9 **a.**

CALCIUM — STRONTIUM — BARIUM

(Practical Chemistry, pp. 376–388, §§ 470–486)

Experiment 184 — Properties of Calcium Carbonate

a. Put a drop or two of dilute hydrochloric acid on one or more specimens of calcium carbonate. State and explain the result.

b. Attach a small lump of marble to a test wire or lay it on a wire gauze, and heat it intensely for ten or fifteen minutes. Test it for a carbonate and state the result. What is the name of the solid product? Write the equation.

c. Add 5 cc. of sodium carbonate solution to 5 cc. of calcium chloride solution. Describe the precipitate. What is it? Write the equation.

Experiment 185 — Tests for Calcium

MATERIALS. — Calcium compounds, ammonium oxalate and sodium carbonate solutions.

a. Apply the flame test to several calcium compounds, using a clean test wire in each case. What is the color of the flame?

b. Add an excess of ammonium oxalate solution to calcium chloride solution, and state the result. The precipitate is calcium oxalate. Divide it into two parts. To (1) add an excess of dilute hydrochloric acid, warm gently, and state the final result. To (2) add considerable acetic acid and warm gently; observe and state the final result. Compare with (1).

c. Add an excess of sodium carbonate solution to calcium chloride solution, and state the result. The precipitate is calcium carbonate. Divide it into two parts, and treat with the acids as in **b.** State the results and compare with **b.**

d. Devise a test for calcium in calcium carbonate and calcium sulphate. Submit the details to the Teacher before proceeding.

Experiment 186 — Testing Substances of Calcium

MATERIALS. — Mortar, plaster, bone ash, plaster of Paris, tooth powder, whiting, cement, bleaching powder.

a. Prepare a solution by boiling a little of each substance with dilute hydrochloric acid (or dilute nitric acid) and filtering. Test the filtrate for calcium by Exp. 185 **b** (or by the flame test). State each result.

b. Test " unknowns " for calcium.

Experiment 187 — Calcium Oxide and Calcium Hydroxide

I. Preparation. — a. Proceed as in Exp. 184 **b.** Let the residue cool, put it in an evaporating dish, and add a little water. Observe the result. Test the liquid with red litmus paper; apply the flame test for calcium. State the results. What calcium compound was formed by heating calcium carbonate? By treating the product with water? Write each equation.

b. Prepare calcium hydroxide by adding water slowly to a lump of lime, and save it for **III.**

II. Properties of Calcium Oxide. — a. Put a lump of fresh calcium oxide on a glass plate or block of wood and let it remain exposed to the air for a few days. Examine it at intervals and describe it. Describe the final product. What is it?

b. What is the result of mixing calcium oxide and water? Write the equation.

III. Properties of Calcium Hydroxide. — a. Add a little solid calcium hydroxide to a test tube half full of water and shake vigorously. Let the suspended solid settle somewhat, and filter. Pour half of the filtrate into an evaporating dish and evaporate it to dryness; save the other half. (Meanwhile **b** may be performed.) When evaporated, compare the amount of residue in the dish with the amount of solid originally shaken with water. Draw a conclusion regarding the solubility of calcium hydroxide in water.

b. Taste cautiously of the solution saved from **a**, and describe the taste. Determine the reaction toward litmus; is the solution acid, alkaline, or neutral? Is the reaction marked? Heat the solution slowly to boiling, and describe the result. What is the effect of increased heat on the solubility of calcium hydroxide in water?

c. State the result of (1) exposing calcium hydroxide solution to the air, and (2) exhaling the breath through calcium hydroxide solution. Express each reaction by an equation.

Experiment 188 — Mortar

MATERIALS. — Lime, sand, old mortar or plaster.
APPARATUS. — Bottle fitted with cork.

a. Prepare slaked lime by adding hot water slowly to about 30 gm. of lime. Add just enough water to make a stiff paste. Add about 50 gm. of sand, more water if necessary, and mix well. Divide into three portions. Spread one portion upon a piece of brick, press another piece of brick upon it, and let the whole remain undisturbed for several days. State the final result.

b. Spread another portion in a thin layer on a board or a glass plate, and let it remain as in **a**. Test it finally for a carbonate and state the result.

c. Put the third portion in a bottle and cork tightly. In a day or two test as in **b**. Compare the results of **b** and **c**.

d. Test a lump of old mortar or plaster for a carbonate and state the result.

Experiment 189 — Properties of Cement

a. Mix a little cement with enough water to form a thick paste and spread the paste in a thin layer on a block of wood or a glass plate. Let it remain undisturbed for a day or more, then examine, describe, and explain.

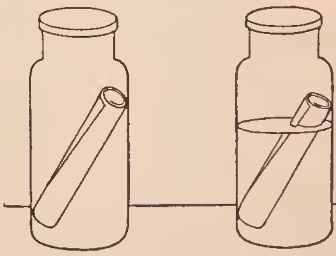


FIG. 90. — Hardening cement — in air (left), in water (right)

b. Prepare two paper cylinders by rolling a sheet of paper around a test tube. Close one end by folding over the edges of the paper. Fill an evaporating dish nearly half full of cement, add about the same bulk of sand, and mix well. Add water and stir until a soft paste is formed. Pour half the mixture into each paper cylinder and slip an elastic band over the upper end to hold the paper in place. Lower one cylinder into a bottle of water and the other into an empty bottle (Fig. 90). Let both stand for a day or two. Then remove, unroll the paper, and compare the contents. State the result. What property of cement is shown by this experiment?

Experiment 190 — Analysis of Cement

MATERIALS. — Cement, solutions for **c** and **d**.

a. Preparation of Sample.—Put about 1 gm. of cement in an evaporating dish, add concentrated hydrochloric acid, and heat (in

the hood) until the cement dissolves. (Filter, if not clear.) Then evaporate to dryness, add a little dilute hydrochloric acid and 25 cc. of water, and warm gently. Filter and wash the precipitate with a little water. Save the precipitate for **b** and the filtrate for **c**.

b. Silica. — Test the precipitate for silica by Exp. 156. State the result.

c. Aluminium and Iron. — To the filtrate from **a** add ammonium hydroxide to alkaline reaction, warm, and filter. Save this filtrate for **d**. Proceed with the precipitate as in (1) and (2).

(1) Dissolve a portion of the precipitate in sodium hydroxide solution and add ammonium chloride solution; the precipitate is aluminium hydroxide. Describe it.

(2) Dissolve another portion in dilute hydrochloric acid, add a little concentrated nitric acid, and boil. Cool and add a little potassium sulphocyanate solution; the red color of the liquid is due to ferric sulphocyanate, and its formation is a test for iron.

d. Calcium. — To the filtrate from **c** add ammonium chloride solution, ammonium hydroxide, and then considerable ammonium oxalate solution. State the result.

Experiment 191 — Calcium Compounds and Hardness of Water

MATERIALS. — Calcium hydroxide, solutions of soap, calcium sulphate, sodium carbonate, and borax.

APPARATUS. — Carbon dioxide generator (see Fig. 68).

a. Temporary Hardness. — Prepare a solution of acid calcium carbonate by passing carbon dioxide into a mixture of 25 cc. of saturated calcium hydroxide and 25 cc. of water (distilled or good quality) until the precipitate is formed and redissolved (see Exp. 121).

(1) To 15 cc. of the clear acid calcium carbonate solution add 5 cc. of soap solution. Shake well and observe the result. Describe the product. Rub some between the fingers and describe the result.

(2) Boil vigorously 15 cc. of acid calcium carbonate solution for a few minutes, filter, and add 5 cc. of soap solution. Shake well and observe the result. Compare the results of (2) and (1).

(3) To 10 cc. of clear acid calcium carbonate solution add 5 cc. of saturated calcium hydroxide, shake, filter, and to the clear filtrate add 5 cc. of soap solution. Shake well and observe the result. Compare the results of (3), (2), and (1).

b. Permanent Hardness. — (1) Proceed as in **a** (1), using 15 cc. of calcium sulphate solution (instead of acid calcium carbonate solution). Compare the results of **b** (1) and **a** (1).

(2) Boil 15 cc. of calcium sulphate solution, add 5 cc. of soap solution, and shake. Compare the results of **b** (2), **b** (1), and **a** (2).

(3) To 15 cc. of calcium sulphate solution add 10 cc. of sodium carbonate solution, filter, add 5 cc. of soap solution, and shake well. Compare the results of **b** (3) and **b** (2).

c. Optional. Try the effect of (1) ammonium hydroxide (in excess, as told by the odor), and (2) borax solution on both temporarily and permanently hard water.

Experiment 192 — Plaster of Paris

MATERIALS. — Plaster of Paris, vaseline.

Mix a little plaster of Paris with enough water to form a thick paste. Put the paste on a block of wood or a glass plate. Rub a very little vaseline on one side of a coin, and press the coin, coated side down, into the paste. Let it stand undisturbed for fifteen or more minutes. Then remove the coin carefully, and examine and describe the effect on the hardened plaster.

Experiment 193 — Tests for Strontium and Barium

MATERIALS. — Strontium compounds, calcium sulphate solution; barium compounds, potassium dichromate solution, acetic acid.

A. Strontium. — a. Apply the flame test to strontium nitrate and other available strontium compounds, using a clean test wire in each case. How is the flame colored? Compare with the color produced by calcium compounds.

b. To the solution of a strontium compound add calcium sulphate solution. The precipitate is strontium sulphate. Write the equation.

B. Barium. — a. Proceed as in **A a**, using barium nitrate and other available barium compounds.

b. Add dilute sulphuric acid to barium chloride solution (or the solution of any barium compound). The precipitate is barium sulphate. Describe it. Test its solubility by heating a little of the precipitate in concentrated hydrochloric acid. State the result.

c. Add potassium dichromate solution to barium nitrate solution. The precipitate is barium chromate. Describe it. Test its solubility by heating some of the precipitate separately in acetic acid and concentrated hydrochloric acid. State the results.

Experiment 194 — Red Fire and Green Fire

(Demonstration Experiment)

MATERIALS. — Strontium nitrate, powdered potassium chlorate, powdered shellac, barium nitrate.

a. Mix carefully small and equal (in bulk) quantities of strontium nitrate, potassium chlorate, and shellac on a sheet of paper. Place the mixture in an iron pan or on a brick in the hood, and set it afire. Describe the result, especially the color.

b. Proceed as in **a**, using barium nitrate instead of strontium nitrate.

IRON

(Practical Chemistry, pp. 391–413, §§ 487–510)

Experiment 195 — Properties of Iron

MATERIALS. — Cast and wrought iron, steel; iron wire, thread, and powder; special steels.

APPARATUS. — Electric bell and battery, magnet.

a. Examine typical specimens of cast iron, wrought iron, and steel, and state their characteristic physical properties.

b. Hold a piece of iron wire in the flame for a minute or two. Is iron a good conductor of heat? Introduce a piece of iron wire into the circuit with an electric bell. Is iron a good conductor of electricity?

c. Determine the specific gravity of a sample of iron and of steel by the method given in Exp. 104 **b**.

d. Try the action of a magnet on iron and steel. State the result.

e. Drop a pinch of iron powder into a Bunsen flame. Hold a piece of iron thread in the flame. Describe the results, and draw a conclusion.

f. Perform, recall, or repeat (if necessary) experiments which show the action of heated iron and (1) oxygen, (2) chlorine, (3) nitrogen, (4) nitrous oxide, and (5) sulphur. State each result.

g. As in **f**, experiments showing the action of acids with iron. State the results.

h. Test the hardness of (1) different varieties of steel and (2) special steels by striking them with a hammer.

Experiment 196 — Analysis of Slag

Pulverize a sample of slag (or use mineral wool) and test it for (1) silica (Exp. 156) and (2) calcium. State each result.

Experiment 197 — Tests for Ferrous Compounds

MATERIALS. — Iron powder (or filings), solutions of sodium hydroxide and potassium ferricyanide.

Put 1 or 2 gm. of iron in a test tube, add about 10 cc. of dilute hydrochloric acid, and warm gently; ferrous chloride is formed (in solution). Proceed at once with the tests.

(1) Pour a little ferrous chloride into a test tube one-third full of sodium hydroxide solution and shake. The precipitate is ferrous hydroxide. Note the color. Shake, and describe the changes in color.

(2) Add 5 cc. of ferrous chloride to 5 cc. of potassium *ferri*cyanide solution. The precipitate is ferrous ferricyanide. Note the color.

Experiment 198 — Tests for Ferric Compounds

MATERIALS. — Solutions of ferric chloride, sodium hydroxide, potassium sulphocyanate, and potassium ferrocyanide.

(1) Add 5 cc. of sodium hydroxide solution to 5 cc. of ferric chloride solution. The precipitate is ferric hydroxide. Note the color.

(2) To 5 cc. of ferric chloride add 5 cc. of potassium *ferro*cyanide solution. The precipitate is ferric ferrocyanide. Note the color.

(3) Add 5 cc. of potassium sulphocyanate solution to 5 cc. of ferric chloride solution. The wine-red colored solution is caused by soluble ferric sulphocyanate. This test readily distinguishes ferric from ferrous compounds.

Experiment 199 — Reduction and Oxidation of Iron Compounds

MATERIALS. — Ferric chloride solution, zinc, ferrous sulphate, potassium chlorate.

a. Put a piece of zinc in ferric chloride solution made slightly acid by hydrochloric acid. After the operation has proceeded for about fifteen minutes, test separate portions of the solution for a ferrous and a ferric compound by Exps. 197 (2) and 198 (3). State and explain the results.

b. (1) To a solution prepared from fresh, or freshly washed, ferrous sulphate add a little hydrochloric acid, warm gently, and then add a few crystals of potassium chlorate. After heating a short time, test separate portions of the solution for a ferric and ferrous compound (as in **a**). State and explain the results.

(2) Add 10 cc. of concentrated nitric acid, drop by drop, to a hot solution of ferrous sulphate to which a little sulphuric acid has been added, and boil. Test and explain as in (1).

Experiment 200 — Hydrolysis of Ferric Chloride

Test ferric chloride solution with litmus paper (both kinds). State and explain the result. Compare with Exp. 175.

Experiment 201 — Testing for Iron

MATERIALS. — Clay, brick, flower pot, bauxite, rusty rock, rouge, sheet tin, iron rust, bluing, solutions of potassium ferricyanide and potassium sulphocyanate.

a. Prepare a solution of the solids by boiling a little of the powdered material with concentrated hydrochloric acid. Test the clear solution for iron, both ferric and ferrous, and state the result in each case.

b. Obtain "unknowns" and test them for iron as in **a**.

c. Add considerable sodium hydroxide solution to a dilute solution of bluing. Describe and explain the result.

ALUMINIUM

(Practical Chemistry, pp. 415–424, §§ 511–524)

Experiment 202 — Properties of Aluminium

a. Proceed with aluminium as in Exp. 195 **b**, **c**, **d**.

b. Warm a piece of aluminium with concentrated hydrochloric acid. Test the escaping gas with a blazing joss stick. What is the gas? What compound of aluminium is formed?

c. Boil a piece of aluminium with concentrated sodium hydroxide solution. Test as in **b**. Answer the questions in **b**.

Experiment 203 — Aluminium Hydroxide

MATERIALS. — Solutions of aluminium sulphate, ammonium hydroxide, sodium hydroxide, potassium hydroxide, ammonium sulphide, and sodium carbonate.

I. Preparation. — **a.** Add ammonium hydroxide to a solution of aluminium sulphate, and shake well. The precipitate is aluminium hydroxide; save it for **II**.

b. Proceed as in **a**, using aluminium sulphate solution and a very little sodium hydroxide solution. Compare with the result in **a**. Save this precipitate for **II**.

II. Properties.— **a.** Examine the precipitate from **I a** and note its properties, *e.g.* color, texture, etc. Remove a little and rub it between the fingers; describe the result.

b. To the precipitate from **I b** add sodium hydroxide slowly and shake constantly until the precipitate dissolves. What aluminium compound is formed?

c. To a portion of the precipitate from **I a** add considerable ammonium hydroxide, and shake well. Compare with the result in **II b**.

d. Add dilute hydrochloric acid to a portion of the precipitate from **I a**, and shake well. State the result. Proceed similarly with other acids, *e.g.* sulphuric and acetic. State the results.

Experiment 204 — Clarification of Water

See Exp. 26 **c**.

Experiment 205 — Thermit (Demonstration Experiment)

MATERIALS. — Thermit, granulated aluminium, barium dioxide, magnesium ribbon.

APPARATUS. — Sand crucible 10 cm. (4 in.) deep, brick, sand, iron pan.

Caution. — Perform this experiment carefully. The molten metal may spatter.

Fill an iron pan with sand and stand it on a brick. Bury the crucible about halfway in the sand; a box of sand should be near by in case the crucible should break.

Put about 30 gm. of thermit in the crucible. Prepare a fuse mixture by mixing thoroughly about 5 gm. of barium dioxide and 0.5 gm. of granulated aluminium. Make a hole in the top of the thermit and pour in the fuse mixture; insert a piece of magnesium ribbon into the heap of fuse mixture. Light the magnesium with the Bunsen flame, and stand aside immediately. The reaction is vigorous. Describe it.

When the crucible is cool, break it open and examine the contents. Describe the two parts. What is the name of each?

Experiment 206 — Tests for Aluminium

MATERIALS. — Aluminium sulphate, cobaltous nitrate solution, charcoal.

a. Proceed as in Exp. 203 **I a**, using an aluminium solution.

b. To a portion of the aluminium solution add a little sodium hydroxide solution and then an excess. To another portion add an excess of ammonium hydroxide. Note each result.

c. Heat a little aluminium sulphate (or any other aluminium compound) on charcoal in the blowpipe flame (oxidizing — see Exp. 134 **B**). Cool, and moisten with a drop or two of cobaltous nitrate solution. Heat again, and note the color of the residue.

Experiment 207 — Preparation and Properties of Alum

MATERIALS. — Aluminium sulphate, potassium sulphate.

I. Preparation. — Mix 8 gm. of aluminium sulphate and 4 gm. of potassium sulphate, and dissolve the mixture in about 50 cc. of hot water. Pour the solution into dish or beaker (Fig. 91) and set it aside to crystallize; well-formed crystals may be obtained upon a thread suspended in the solution. (Meanwhile proceed with **II a**, etc.). Crystals of potassium alum will be deposited. Remove the best ones; dry and examine. Describe them, giving color, luster, size, and crystal form.

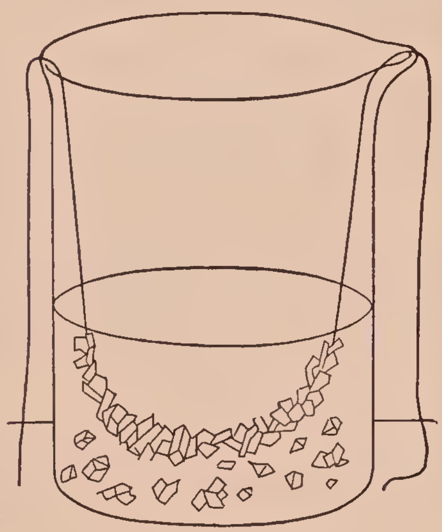


FIG. 91. — Crystallizing alum

II. Properties. — **a.** Test a solution of alum separately for aluminium and sulphate ions, and state the result. Cautiously taste the solution, and describe the result.

b. Test alum for water of crystallization, and state the result.

c. Select several good crystals from those prepared in **I** and examine them carefully. Describe them. Test as in **II**, and state the results. Allow some crystals to remain exposed to the air for several hours. Compare finally with the original crystals. Explain the difference.

Experiment 208 — Aluminium Salts as Mordants

MATERIALS. — Solutions of alum, cochineal, and aluminium acetate; alizarin paste, cotton cloth.

a. Add a little alum solution to a dilute solution of cochineal, then add ammonium hydroxide and shake well. Filter, and compare the colors of the filtrate and precipitate.

b. Boil two small pieces of cotton cloth for several minutes thoroughly in water. Remove the excess of water. (1) Put one piece in a dish or beaker, add 50 cc. of water and 5 cc. of alizarin paste, and heat nearly to the boiling point for about two minutes. Wash the cloth in water, dry, and then examine. (2) Now proceed in the same way with a piece of cotton cloth which has been previously mordanted by boiling for about two minutes in aluminium acetate solution. Compare the two pieces of cloth. Explain.

Experiment 209 — Hydrolysis of Aluminium Salts

Test a solution of aluminium sulphate and of alum with litmus paper. State and explain each result. Compare with Exps. 175 and 200.

COPPER

(Practical Chemistry, pp. 426–437, §§ 525–527)

Experiment 210 — Properties of Copper

Apparatus. — Electric bell and battery, magnet.

a. Proceed with copper as in Exp. 195, **b**, **c**, **d**.

b. Heat a piece of copper wire in the flame until it burns. Note the color. What compound is formed?

c. What is the effect of dilute nitric acid on copper?

Experiment 211 — Tests for Copper

Materials. — Copper wire, copper sulphate solution, ammonium hydroxide, acetic acid, potassium ferrocyanide solution.

a. Heat a copper wire, or a copper compound in the Bunsen flame, and observe the color imparted to the flame.

b. Add considerable ammonium hydroxide to copper sulphate solution, shake well, and observe the result. The formation of the blue solution is the usual test for copper.

c. Add to a test tube one-fourth full of water an equal volume of copper sulphate solution, and shake; then add a few drops of acetic acid and of potassium ferrocyanide solution. The brown precipitate is cupric ferrocyanide ($Cu_2Fe(CN)_6$).

Experiment 212 — Properties of Copper Sulphate

a. Examine a typical specimen of crystallized copper sulphate, and state its characteristic properties. See also Exps. 42, 43.

b. Let red and blue litmus paper remain in copper sulphate solution for fifteen minutes or more. State and explain the result. Compare Exps. 175, 200, 209.

Experiment 213 — Tests for Copper in Alloys

MATERIALS. — Brass, aluminium bronze, German silver, American cent, nickel, and dime.

a. Prepare a solution of one of the alloys enumerated above by boiling a small piece in dilute nitric acid; it may be necessary to treat the alloy with several portions of acid. Filter the final liquid if it is not clear. Apply the test for copper to the clear solution as in Exp. 211 **b**. Be sure to add an excess of ammonium hydroxide and shake well. State the result in each case.

b. Proceed as in **a** with "unknowns" and with metallic substances suspected to contain copper, *e.g.* pins and inexpensive jewelry.

Experiment 214 — Displacement of Metals — Copper

MATERIALS. — Copper wire, iron nail, zinc, copper sulphate solution, mercuric chloride solution (POISON).

a. Put a clean copper wire in a test tube half full of mercuric chloride solution (POISON). After a short time remove the wire and wipe it with a soft cloth or paper. Observe and explain the change.

b. Put a clean iron nail in a test tube half full of copper sulphate solution. After a short time remove the nail and examine it. What is the deposit? Explain its formation.

c. Repeat **b**, using a strip of zinc instead of an iron nail. Observe and explain the result.

REQUIRED EXERCISE. — Arrange the metals (used in this experiment) in the order of their displacing power with reference to copper.

MAGNESIUM — ZINC — MERCURY

(Practical Chemistry, pp. 439–450, §§ 538–560)

Experiment 215 — Properties of Magnesium and Zinc

a. Proceed with magnesium and zinc as in Exp. 195 **b**, **c**, **d**.

b. Perform, recall, or repeat (if necessary) experiments showing the results of heating magnesium and zinc (1) in a limited supply of air and (2) in an abundance of air; and also treating magnesium and zinc with acids. State the results.

Experiment 216 — Tests for Magnesium

MATERIALS. — Solutions of magnesium sulphate, ammonium chloride, ammonium hydroxide, discdium phosphate.

a. To a solution of a magnesium compound, *e.g.* magnesium sulphate, add successively solutions of ammonium chloride, ammonium hydroxide, and disodium phosphate. A precipitate of ammonium magnesium phosphate (NH_4MgPO_4) is formed. Describe it.

b. Heat a little magnesium sulphate on charcoal, in a blowpipe flame, as in Exp. 206 **c**. Note the color of the residue. Compare with Exp. 206 **c**.

Experiment 217 — Testing for Magnesium

MATERIALS. — Magnesia ("85 per cent"), substances as in **b**.

a. Boil a gram or two of "85 per cent magnesia" pipe covering with dilute hydrochloric acid. Filter and test the filtrate (diluted) for magnesium. State the result.

b. Proceed as in **a** with (1) magnesia, (2) milk of magnesia, (3) flashlight powder, (4) Epsom salts, (5) magnesite. State each result.

Experiment 218 — Tests for Zinc

MATERIALS. — Zinc, zinc sulphate and cobalt nitrate solutions, zinc oxide, blowpipe, charcoal.

a. Apply tests for metallic zinc (see Exp. 215).

b. Add a very little sodium hydroxide solution to a solution of a zinc compound, *e.g.* zinc sulphate, and shake well. Describe the precipitate. What is it? Divide the mixture into three parts. (1) To one add considerable sodium hydroxide, (2) to another add ammonium hydroxide, and (3) to the third add dilute hydrochloric acid. Shake each well, and observe the result. What is the name and formula of the zinc compound formed in (1) and (3)?

c. Proceed as in Exp. 206 **c**, using zinc oxide (or any other zinc compound). Note the color on the charcoal. Compare with Exps. 206 **c**, 216 **b**.

d. Add hydrogen sulphide water to zinc sulphate solution and note the color of the precipitate. What is the name of the precipitate? Write the equation.

Experiment 219 — Zinc Hydroxide

MATERIALS. — Solutions of zinc sulphate, ammonium hydroxide, sodium hydroxide, potassium hydroxide, ammonium sulphide, and sodium carbonate.

Proceed as in Exp. 203, using zinc sulphate instead of aluminium sulphate. Compare the behavior of aluminium and zinc hydroxides when treated with ammonium hydroxide.

Experiment 220 — Properties of Mercury

MATERIAL. — Mercury.

a. Pour a drop or two of mercury into an evaporating dish. Examine the mercury, and state its characteristic properties. Agitate the dish, and describe the result.

b. Stand a funnel in a test tube and carefully pour the mercury from the dish into the test tube. Remove the funnel. Heat the bottom of the test tube gently and observe the result, especially the deposit, if any, upon the upper part of the tube. Scrape a little out of the tube with a glass rod. What is the deposit? What property of mercury is shown by this experiment?

c. Suggest a method of determining the specific gravity of mercury. If approved by the Teacher, try it.

Experiment 221 — Mercurous and Mercuric Compounds

MATERIALS. — Solutions of mercurous nitrate, mercuric chloride (POISON), and stannous chloride.

I. **Mercurous.** — **a.** Add a few drops of hydrochloric acid to a little mercurous nitrate solution. The precipitate is mercurous chloride. Describe it. Note its insolubility in water and in dilute hydrochloric acid. Add an excess of ammonium hydroxide. The black precipitate is a test for mercury in mercurous compounds.

b. Add potassium iodide solution to mercurous nitrate solution. Describe the result. Give the name and formula of the mercury compound formed. Write the equation.

II. **Mercuric.** — **a.** Add a few drops of hydrochloric acid to a little mercuric nitrate solution. Compare with the result in **I a**. Add a few drops of ammonium hydroxide, or enough to produce a decided change. Compare with **I b**. The precipitate is mercuric ammonium chloride.

b. Proceed as in **I b**, using mercuric chloride solution (POISON). Compare the results. Give the name and formula of the mercury compound formed. Write the equation.

c. Add a little stannous chloride solution to mercuric chloride and note the result; then add considerable stannous chloride solution

and note the change. Write equations for the reactions. (NOTE. — This is the usual test for mercuric compounds).

Experiment 222 — Displacement of Metals — Magnesium, Zinc, and Mercury

Proceed as in Exp. 214, using these metals and solutions of several metallic compounds, *e.g.* copper sulphate, lead nitrate, silver nitrate, and stannous chloride. Try also other metals and solutions of salts of magnesium, zinc, and mercury. Note each result and prepare a table showing the displacing power of the metals. (Compare Exp. 214.)

TIN — LEAD

(Practical Chemistry, pp. 452–462, §§ 561–578)

Experiment 223 — Properties of Tin and Lead

a. Proceed with tin and lead as in Exp. 195 **b**, **c**, **d**.

b. Bend a piece of tin and note the crackling noise.

c. Heat a small piece of tin in a test tube with concentrated hydrochloric acid in the hood until most of the tin disappears. Stannous chloride is formed. Save this solution for Exp. 224.

d. Add a small piece of tin to a test tube one-fourth full of concentrated nitric acid in the hood. Stand the test tube in the rack as soon as the action begins. The product is metastannic acid. Describe it. Compare the action of nitric acid on tin, copper, and zinc.

e. Heat a small piece of tin with *aqua regia* in a test tube in the hood. Observe the result. What tin compound is formed?

f. Rub a piece of lead on a hard surface, or with the fingers. State the result.

Experiment 224 — Test for Tin

MATERIALS. — Solutions of stannous chloride and mercuric chloride (POISON).

Add a few drops of stannous chloride solution (saved from Exp. 223 **c**) to mercuric chloride solution. The white precipitate is mercurous chloride. Add considerable stannous chloride and warm gently. The gray-black precipitate is finely divided mercury. Write the equations for both reactions.

Experiment 225 — Tests for Lead

Materials. — Lead nitrate and potassium dichromate solutions.

a. Reduce lead oxide (or other lead compounds) in the blowpipe flame. (See Exp. 134 **A a.**)

b. Add hydrogen sulphide solution to a solution of a lead compound. Note the color. Give the name and formula of the precipitate.

c. Add dilute hydrochloric acid to a little lead nitrate solution until precipitation ceases. The insoluble precipitate is lead chloride. Boil some of the precipitate with considerable water. Describe the action.

d. Add dilute sulphuric acid to a little lead nitrate solution until precipitation ceases. Give the name and formula of the precipitate. Observe its properties. Is it soluble in hot water? Try it.

e. Repeat **d**, using potassium dichromate solution instead of sulphuric acid. Give the name and formula of the precipitate. Describe it, especially the color.

Experiment 226 — White Lead

Materials. — Lead monoxide, acetic acid, white lead.
Apparatus. — Carbon dioxide generator.

a. Heat about 15 cc. of acetic acid in a test tube nearly to boiling, and add about 5 gm. of lead monoxide in small portions. Meanwhile do **b**. Shake and heat at intervals until most of the solid disappears. Then add about 5 cc. of water, and filter, if the liquid is not clear. Pass carbon dioxide (free from acid) through the filtrate (see Exp. 120 and Fig. 68), and note the result. What is the name and formula of the product? Filter, and use the precipitate in **c**.

b. Test white lead for (1) lead and (2) a carbonate. State the results.

c. Proceed as in **b** with the precipitate from **a**.

Experiment 227 — Displacement of Metals — Tin and Lead

Proceed as in Exps. 214, 222 using tin and lead with solutions of metals. Tabulate the results and compare with similar experiments.

Experiment 228 — Testing for Lead

a. Warm thin shavings of solder with dilute nitric acid, filter, and test the filtrate for lead.

b. Proceed as in **a** using one or more of the following: Tea lead, type metal, plumbago, shot, bullets, metallic cap of a bottle, "lead" of a lead pencil, and "unknowns."

c. Apply the (reduction) blowpipe test for lead to white lead, red lead, litharge, dry paint, chrome yellow, and "unknowns."

Experiment 229 — Qualitative Analysis of a Solution of Lead, Silver, and Mercury (ous)

MATERIALS. — Solution containing lead nitrate, silver nitrate, and mercurous nitrate; hydrogen sulphide water, potassium dichromate.

a. To 10 cc. of the solution add dilute hydrochloric acid drop by drop until precipitation ceases. Allow the mixture of precipitated chlorides to settle, pour off the liquid carefully, add about 15 cc. of water, boil, and filter. This operation dissolves the lead chloride. Test the filtrate for lead as in **b**; save the precipitate for **c**.

b. To separate portions of the filtrate add hydrogen sulphide water and potassium dichromate solution. Note each result.

c. Wash the precipitate from **a** with hot water until the wash water does not give a test for lead. Then stand the funnel in a clean test tube and pour ammonium hydroxide on the mixture of silver and mercurous chlorides. This operation dissolves the silver chloride. Test the filtrate as in **d**; save the precipitate for **e**.

d. To the filtrate from **c** add dilute nitric acid to acid reaction and shake. The silver compound is precipitated as silver chloride.

e. The black residue on the paper is a sufficient test for mercury. Confirm thus: Pour a little *aqua regia* (mixture of 3 cc. of concentrated hydrochloric acid and 1 cc. of concentrated nitric acid) upon the black precipitate; catch the filtrate in a porcelain dish, dilute with about 5 cc. of water, and add a clean copper wire; remove the wire in a few minutes, wipe gently, and mercury will be seen on the wire as a bright silvery coating.

SILVER — GOLD

(Practical Chemistry, pp. 464–472, §§ 579–595)

Experiment 230 — Tests for Silver

MATERIALS. — Silver coin, hydrogen sulphide, silver nitrate solution.

a. Hold a silver coin at the mouth of a bottle of hydrogen sulphide water, and note the change in color. What silver compound is formed?

b. Add dilute hydrochloric acid to a silver solution, *e.g.* silver nitrate, and shake. Next add considerable ammonium hydroxide and shake, and then add dilute nitric acid to acid reaction. The precipitation of silver chloride, its solubility in ammonium hydroxide, and its reprecipitation by dilute nitric acid constitute the usual test for silver.

Experiment 231 — Displacement of Metals — Silver

Summarize the results of previous experiments in which silver or silver solutions were used.

Experiment 232 — Cleaning Tarnished Silver

Materials. — Silver coin, aluminium, sodium carbonate.

Dissolve 10 gm. of sodium carbonate in about 50 cc. of water and heat to boiling. Put a small piece of aluminium and a tarnished silver coin into the solution; have the metals in contact. Remove and examine the coin after a few minutes. State the result.

Experiment 233 — Preparation and Properties of Silver Halides

Materials. — Solutions of silver nitrate, potassium chloride, potassium bromide, potassium iodide, sodium thiosulphate.

To separate portions of silver nitrate solution add the chloride, bromide, and iodide solution. Observe and state the color of each precipitate. Filter each separately.

Test each precipitate separately by (1) exposing a little to the light, (2) shaking some with ammonium hydroxide, and (3) shaking some with sodium thiosulphate solution. State each result. Compare their behavior under the same conditions.

Experiment 234 — Silver Salts and Photography

Materials. — Dilute silver nitrate (17 gm. to a liter), sodium chloride (5.8 gm. to a liter), and sodium thiosulphate solutions — "hypo" (250 gm. to a liter); commercial developer or a substitute (see App. § 6, List G).

Apparatus. — 4 Test tubes (labeled), black paper, 2 plates (preferably lantern slide plates).

Note. — Owing to the rapid action of silver bromide, silver chloride is used.

a. Add 5 cc. of the silver nitrate solution to 5 cc. of the sodium chloride solution, shake gently, and expose the precipitate to the

light. Examine frequently and note the time needed for a definite change in color.

b. Prepare silver chloride as in **a**, and add also 5 cc. of the developer. Expose, and note the time as in **a**. Compare the times.

c. Wrap a piece of dark paper around a test tube to protect it from the light, and add the three solutions as in **b**. After half a minute, examine quickly and note the color. Examine again after half a minute more. Compare with **b**.

d. Prepare silver chloride as in **a**, add also 5 cc. of "hypo" solution, and shake well. Note the result.

e. Optional. Try **a** to **d** with silver bromide (prepared from dilute silver nitrate and potassium bromide solutions) and compare the results with **a** to **d**.

f. *Demonstration Experiment.* Expose two photographic plates (preferably lantern slide plates) or films, develop both in the dark room with the class, fix one, and later compare both. Make two prints from the fixed plate, and develop. Wash one, and later compare the two prints.

Experiment 235 — Properties of Gold

Materials. — Gold, chlorine water, stannous chloride solution.

a. Proceed as in Exp. 62 **b**. What gold compound is formed? Save the liquid for **c**.

b. Proceed as in Exp. 67. What gold compound is formed? Save the liquid for **c**.

c. Heat (in the hood) the solutions from **a** and **b** until most of the chlorine has been driven off, dilute the final solution with water, and then slowly add a little dilute stannous chloride solution. A purple (or black) precipitate of finely divided gold is produced. Its formation is a test for gold.

CHROMIUM — MANGANESE

(Practical Chemistry, pp. 474–477, §§ 596–605)

Experiment 236 — Tests for Chromium

Materials. — Borax, chrome alum, potassium carbonate, potassium nitrate, acetic acid, nitric acid; sodium hydroxide, lead nitrate, and potassium dichromate solutions.

a. Apply the borax bead test to chrome alum or other chromium compounds (see Exp. 180).

b. Mix equal small quantities of potassium carbonate, potassium nitrate, and powdered chrome alum, place the mixture on a piece of porcelain, hold it with the test tube holder, or stand it on a wire gauze, and heat intensely until the mixture fuses. A yellow mass, due to the presence of potassium chromate, results.

If the color is not marked, dissolve the mass in water, add acetic acid, slowly at first, and then boil until the carbon dioxide is expelled. Add a few drops of lead nitrate solution to a portion, and yellow lead chromate is precipitated. (If the precipitate is white, it is lead carbonate, and shows that not all the potassium carbonate was decomposed, as intended.)

c. Proceed as in Exp. 225 **e**, using potassium chromate or dichromate solution. State the result.

Experiment 237 — Potassium Chromate and Dichromate

MATERIALS. — Potassium chromate and dichromate, concentrated hydrochloric acid, potassium hydroxide solution.

a. Prepare a dilute solution of potassium chromate and dichromate, and compare the colors. Save for **b** and **c**.

b. Add concentrated hydrochloric acid to 5 cc. of the solution of potassium chromate prepared in **a**, shake well, and observe the change in color. Describe it. Compare with the color of the potassium dichromate solution. Into what compound has potassium chromate been changed?

c. Add potassium hydroxide solution to 5 cc. of the solution of potassium dichromate prepared in **a** until a change of color is produced. Describe the color. Compare with the potassium chromate solution. Into what compound was the potassium dichromate changed?

d. Add a few drops of concentrated hydrochloric acid to powdered potassium chromate and dichromate in separate test tubes. What gas is evolved?

Experiment 238 — Tests for Manganese

MATERIALS. — Manganese dioxide, potassium carbonate, potassium nitrate, ammonium sulphide, manganese sulphate solution, hydrochloric acid, acetic acid, ammonium hydroxide.

a. Apply the borax bead test to manganese dioxide (or any other manganese compound — see Exp. 180).

b. Fuse on a piece of porcelain (as in Exp. 236 **b**) a little manganese dioxide mixed with potassium carbonate and potassium nitrate. The green color of the mass is due to potassium manganate.

c. Add ammonium sulphide to manganese sulphate solution. The flesh-colored precipitate is manganese sulphide. Compare with other sulphides as to color (see Exp. 111).

APPENDIX

1. **The Pressure of Water Vapor** in millimeters of mercury is: —

Temperature	Vapor Pressure	Temperature	Vapor Pressure	Temperature	Vapor Pressure
12	10.5	17	14.4	22	19.7
12.5	10.8	17.5	14.9	22.5	20.3
13	11.2	18	15.4	23	20.9
13.5	11.6	18.5	15.9	23.5	21.5
14	11.9	19	16.4	24	22.2
14.5	12.3	19.5	16.9	24.5	22.8
15	12.7	20	17.4	25	23.6
15.5	13.1	20.5	18.0	25.5	24.3
16	13.6	21	18.5	26	25.0
16.5	14.0	21.5	19.1	26.5	25.7

The numbers in the Vapor Pressure columns are the values for a in the formula for the reduction of gas volumes (see the author's *Practical Chemistry*, § 74).

2. **Laboratory Equipment.** — These lists include the apparatus, chemicals, and supplies needed for the experiments in this book. No allowance is made for breakage, duplicate corks and rubber stoppers, and extra glass and rubber tubing.

List A — Individual Outfit. This list includes the articles needed by each pupil (see frontispiece).

1 Blowpipe.
1 Blowpipe tube.
1 Beaker, 250 cc.
5 Bottles, wide mouth, 250 cc.
1 Bottle, generator, 250 cc.
1 Bunsen burner.
1 Cork to fit smaller test tube.
1 Cork to fit larger test tube.
1 Crucible and cover, porcelain, No. 0.
1 Crucible block, wood, 10 × 10 × 2.5 cm. with 3 cm. hole in center.
1 Deflagrating spoon.
1 Evaporating dish, 7 cm.
1 Flask, Erlenmeyer, 250 cc.
100 Filter papers, 10 cm.
1 Forceps, iron.
1 Funnel, 65 mm.
4 Glass plates, 10 × 10 cm.

1 Glass plug (see Exp. 55).
1 Glass rod, 15 cm.
1 Glass tube, 150 cm.[1]
1 Graduated cylinder, 25 cc.
1 Iron stand, clamp (medium), ring (8 cm.).
1 Matches (box).
1 Mortar and pestle, 8 cm.
1 Pinch-clamp, Mohr's.[2]
1 Pneumatic trough, complete.[3]
1 Rubber stopper, 23 mm., 1-hole.[4]
2 Rubber stoppers, 23 mm., 2-hole.[4]
1 Rubber tube, 6 mm. ($\frac{1}{4}$ in.) diam., 60 cm. long (for burner).
1 Rubber tube, $\frac{3}{16}$ in. diam., 15 cm. long (for connectors).
1 Rubber tube, pressure ($\frac{3}{16}$ in. diam.), 15 cm. long (for dropping funnel).[2]
1 Sponge.
12 Test tubes, 15 × 1.8 cm. (6 × $\frac{3}{4}$ in.) ("small" test tube).
3 Test tubes, 20 × 2.5 cm. (8 × 1 in.) ("large" test tube).
1 Test tube brush.
1 Test tube holder.
1 Test tube rack.
1 Test wire (see Int. **5**, **d**.).
1 Thistle tube, straight stem.[2]
1 Triangle.[5]
1 Wire gauze, 10 × 10 cm.
2 Wooden blocks, 15 × 15 × 2.5 cm.

List B — Special Apparatus. This list includes the special apparatus needed for a class of ten. Numbers in parentheses refer to experiments.

1 Balance, chemical (**24**, **51**, **52**, **87**–**93**, **125**.
3 Balances, horn pan (as above).[6]
1 Barometer (**24**, **87**–**91**, etc.).
4 Beakers, 250 cc. (**75**).
1 Bottle, 750 cc. (**87**).
5 Bottles, 2500 cc.
4 Burettes, 50 cc. (**75**).
1 Burner, gas (**131**).
3 Chimneys, lamp.
1 Cork borers, set (Int. § **5 c**).
1 Cylinder, graduated, 1000 cc.
2 Cylinders, graduated, 500 cc.
2 Cylinders, graduated, 250 cc.
2 Cylinders, graduated, 100 cc.
5 Crucibles, Hessian, 10 cm. deep (**11**).
5 Crucibles, iron, 60 cc. (**124**, **146**, **154**).
2 Desiccators (optional) (**93**).
5 Dishes, lead (**156**, **158**).
2 Electric bells (**195**, etc.).
4 Electrodes, carbon.
1 File, round (Int. § **5 c**).
1 File, triangular (Int. § **3** a).
3 Flasks, Erlenmeyer, 125 cc. (**87**).
1 Hydrometer (heavy) (**38**, **114**).
1 Hydrometer (light) (**126**, **139**).
3 Jars, 30 × 10 cm. (**89**, **91**).
3 Lenses (magnifiers) (**3**, **40**, **106**).
2 Magnets (**3**, **195**, etc.).
5 Pans, iron, 10 cm.
3 Retorts, stoppered, 250 cc. (**81**).

[1] To fit the rubber stoppers. [2] See Exp. 14. The stem of the thistle tube should fit the rubber stoppers. [3] Preferable kind is an indurated fiber Keeler No. 4 provided with a shallow flower pot 10 cm. in diameter. An agateware pan may be used. [4] To fit the larger test tube. This size (about 23 mm.) also fits the average 250 cc. Erlenmeyer flask, the 250 cc. generator bottle and the 2500 cc. bottle (acid bottle — See List B). [5] To fit porcelain crucible.
[6] A chemical balance costing about twenty-five dollars is sufficiently accurate. Horn pan balances, if carefully counterpoised, give acceptable results. (Int. § 8).

3 Rubber stoppers, 1 hole (for 125 cc. Erlenmeyer flask) (**87**).
2 Scales (Int. § **8**) (constantly).
3 Screws, Hofmann (**24**).
3 Thermometers, $-10°$ to $100°$ C. (frequently).
5 Tubes, graduated, 100 cc. (**89, 91**).
3 Watch glasses, 9 cm. (**92, 93**).
1 Weights for chemical balance, 2 mg. to 50 gm.
3 Weights for horn pan balance, 2 mg. to 50 gm.
3 Weights for scales, 5 gm. to 1000 gm.
3 Wing-top burners (Int. § **3 b**).

List C — Demonstration Apparatus. This list includes apparatus — not in other lists — needed for the demonstration experiments. Numbers in parentheses refer to experiments.

1 Babcock apparatus complete (**152**).
1 Battery (**49, 61, 94, 96–99, 178**).
1 Battery jar, 12 cm. in diam. (**61, 178**).
1 Chlorine tube (**48**).
1 Clamp (large — for condenser) (**28 I**).
1 Condenser, Liebig, complete (**28 I**).
2 Electric light bulbs (**94, 103**).
1 Fire extinguisher (**17**).
1 Flask, 500 cc. (**16**).
1 Funnel, dropping, 100 cc. (**103**).
1 Hofmann apparatus (**49, 97, 98**).
1 Jar, oblong (**103**).
1 Platinum tip (optional) (**22**).
1 Platinum wire (optional) (**22**).
1 Siphon of charged water (**15**).
3 Stoppers, rubber, 1 hole, for U-tube (**22**).
1 Tube, capillary, 8 cm. (**22**).
1 Tube, U-, 10 cm. (**22**).

List D — Chemicals. This list includes the quantities of chemicals needed for a class of ten. Numbers in parentheses refer to experiments. Starred items may be bought of a local dealer.

Acid, acetic	250 cc.
hydrochloric	5 l.
nitric	1.5 l.
orthophosphoric	25 gm.
oxalic (**123**)	100 gm.
pyrogallic (**55**)	50 gm.
sulphuric	2.5 l.
Albumin	25 gm.
Alcohol, ethyl[1]	1 l.
methyl	100 cc.
Alizarin (paste) (**208**)	10 gm.
Alloys, fusible (**170**)	25 gm.
Alum	200 gm.
chromium	25 gm.
Aluminium acetate	25 gm.
bronze (**213**)	25 gm.
chloride	50 gm.
granulated (**205**)	25 gm.
lump (**202**)	100 gm.
sheet	600 sq. cm.
sulphate	200 gm.
wire	1 m.
Ammoniacal liquor	150 cc.
Ammonium carbonate	150 gm.
chloride	500 gm.
dichromate (**102**)	25 gm.
hydroxide	2.5 l.
molybdate	25 gm.
nitrate (**86**)	150 gm.
oxalate	50 gm.
sulphate	25 gm.
sulphide	100 cc.

[1] Denatured alcohol is suitable for many experiments.

Aniline (**34**)	50 cc.
Antimony chloride (**168**)	25 gm.
Arsenic trioxide	25 gm.
Asbestos, shredded (**24**)	5 gm.
Baking powder (**153**)*	250 gm.
Barium carbonate (**80**)	25 gm.
chloride	150 gm.
chloride (pure) (**71**)	25 gm.
dioxide (**5**, **205**)	25 gm.
hydroxide (solid)	25 gm.
nitrate	100 gm.
sulphate (**135**)	25 gm.
Bauxite (**201**)	50 gm.
Bismuth chloride	25 gm.
Bleaching powder*	250 gm.
Bone ash	25 gm.
Borax*	500 gm.
Brass (**213**)*	25 gm.
Cadmium nitrate	25 gm.
Calcite (**87**)	100 gm.
Calcium (**76**, **91**)	50 gm.
carbonate (marble)*	2.5 kg.
chloride	200 gm.
cyanamide (**78**)	25 gm.
fluoride	200 gm.
oxide (lime)*	500 gm.
sulphate	150 gm.
Camphor (**139**)*	25 gm.
Carbon disulphide	500 cc.
tetrachloride	500 cc.
Carborundum, lump	25 gm.
powder	25 gm.
Cement*	1 kg.
Chalk (**122**)	25 gm.
Charcoal, animal	100 gm.
blocks	15 blk.
wood (powd.)	150 gm.
Chloroform	100 cc.
Chrome yellow*	25 gm.
Cobalt chloride (cryst.)	25 gm.
nitrate	50 gm.
Cochineal	1 gm.
Copper borings	200 gm.
bromide	25 gm.
nitrate	25 gm.
oxide (ic)	100 gm.
sheet*	50 sq. cm.
sulphate	750 gm.
wire (No. 20)*	250 gm.
Cream of tartar*	25 gm.
Dextrose. *See* Glucose	
Electrosilicon (**156**)	25 gm.
Ether	250 cc.
Ferric chloride	50 gm.
Ferrous sulphate	100 gm.
sulphide	500 gm.
Gasolene*	2.5 l.
Gelatin*	25 gm.
German silver	25 gm.
Glass wool (**24**, **156**)	5 gm.
Glycerin	100 cc.
Glucose	150 gm.
Gold leaf	1 bk.
Graphite	250 gm.
Hydrogen peroxide*	500 cc.
Hydroquinone (**234**, List G)	15 gm.
Iodine	50 gm.
Infusorial earth (**156**)	25 gm.
Iron filings	50 gm.
powder	200 gm.
thread (steel wool)	50 gm.
Joss sticks*	5 pkg.
Kerosene*	500 cc.
Lead dioxide	100 gm.
monoxide (litharge)*	150 gm.
nitrate	100 gm.
red (tetroxide)*	75 gm.
sheet (thin)*	75 gm.
sulphate (**135**)	25 gm.
tea (**21**, **228**)*	2500 sq. cm.
white (carbonate)*	50 gm.
Litmus cubes	5 gm.
paper (each color)	6 sheets
Magnesium carbonate (**217**)	25 gm.
chloride	25 gm.
oxide	25 gm.
powder (**51**)	25 gm.
ribbon	25 gm.
sulphate	100 gm.
Manganese dioxide (gran.)	750 gm.
dioxide (powd.)	50 gm.
sulphate	25 gm.

Mercury	25 gm.
chloride (ic)	25 gm.
nitrate (ous)	25 gm.
oxide (**4**)	25 gm.
Mineral wool (**156**)	10 gm.
Naphthol (Alpha). *See* List G.	25 gm.
Nickel chloride	25 gm.
sulphate	25 gm.
Paraffin wax*	25 gm.
Phenol-phthalein solution	150 cc.
Phosphorus, yellow	25 gm.
Plaster of Paris*	150 gm.
Potassium	1 gm.
bromide	100 gm.
carbonate	150 gm.
chlorate (cryst.)	250 gm.
chlorate (powd.)	200 gm.
chlorate (pure) (**71**)	25 gm.
chloride	200 gm.
chromate	25 gm.
dichromate (*See also* Battery Solution, List G)	250 gm.
ferricyanide	50 gm.
ferrocyanide	50 gm.
hydroxide	150 gm.
iodide	100 gm.
nitrate	200 gm.
nitrite	50 gm.
perchlorate	25 gm.
permanganate	50 gm.
sulphate	100 gm.
sulphocyanate	25 gm.
Pumice*	10 gm.
Rosin (**139**)*	25 gm.
Shellac (powd.)*	50 gm.
Silver nitrate	50 gm.
sulphate (**95**)	25 gm.
Soda lime	250 gm.
Sodium	10 gm.
acetate (**142**)	25 gm.
bicarbonate*	250 gm.
carbonate*	500 gm.
chloride	2 kg.
chloride (pure) (**71**)	25 gm.
citrate (*See* Fehling's Solution, List G)	100 gm.
cobaltinitrite (**182**) *See* List G.	
dichromate	25 gm.
hydroxide	750 gm.
hypochlorite (solution)	150 cc.
nitrate	500 gm.
nitrite	100 gm.
peroxide	25 gm.
phosphate (disodium)	25 gm.
silicate (solution)	150 cc.
sulphate	150 gm.
sulphite	200 gm.
thiosulphate ("hypo")	300 gm.
Solder*	50 gm.
Stannous chloride. *See* List G.	50 gm.
Starch*	250 gm.
Strontium nitrate	50 gm.
Sugar (cane)*	500 gm.
Sulphur, flowers	250 gm.
roll	750 gm.
Tannin	25 gm.
Tartar emetic	25 gm.
Thermit (**205**)	25 gm.
Tin, granulated (**83**)	100 gm.
rod (**223**)	25 gm.
Turpentine*	50 cc.
Type metal (**228**)*	50 gm.
Water, distilled	3 l.
Whiting (**122**)*	25 gm.
Zinc chloride	25 gm.
dust (**8**)	25 gm.
granulated	1 kg.
oxide	25 gm.
sheet*	200 gm.
sulphate	50 gm.

List E — Miscellaneous Supplies. The quantities are usually small. Numbers in parentheses refer to experiments. Household ammonia, banana, beans, bluing (201), bullets (228), butter, candle, candy, carrot, celery, clay, colored and unbleached cloth, hard and soft coal, cotton, cracker, cranberry, fertilizer (165), flash light powder

(217), flour, flower pot (201), grape juice (73), hair, horn, cast iron (195), iron nails, iron ores, iron rust, iron wire (195), wrought iron (195), junket tablet (152), karo (13), lard (144), lemon, limestone, lye (144), magnesia covering (217), milk of magnesia (217), magnesite (217), maple sugar, phosphorus tipped matches, meat, milk, molasses, old mortar (122), nut butter (151), dry paint (228), (colored) paper, peas, phosphate rock (166), plaster (186), plumbago (116), potash, potato, quill toothpick, raisins, rice, rusty rock (200), rouge (200), sand, shot (228), slag (196), soap, scouring soap, steel (195), stove polish, tacks, (wax) taper, thread, tooth powder, turnip, vaseline, vinegar, yeast cake.

List F — Emergency Supplies (see Int. § 11). 25 gm. absorbent cotton, 12 bandages (5 cm.), blanket, 50 gm. boric acid solution, 25 gm. camphor solution, 250 gm. carron oil, 12.5 gm. collodion, 1 book court plaster, fire extinguisher, 1 pkg. gauze (picric acid), medicine dropper, 1 paper pins, sand and scoop, scissors, 1 bottle smelling salts, 250 gm. sodium bicarbonate, 1 spool thread, 25 gm. vaseline.

List G — Solutions. The solutions needed for most experiments are approximately 10 per cent. The concentration of special solutions is usually given in the directions for the experiments. Certain solutions should be made as follows:

Acetic acid, dilute, 1 vol. to 5 vols. of water.
Ammonium carbonate. Dissolve 250 gm. in 1000 cc. of water and add 85 cc. of ammonium hydroxide.
Ammonium hydroxide, 1 vol. to 3 vols. of water.
Ammonium molybdate. Dissolve 15 gm. in 100 cc. of water and pour this solution into 100 cc. of nitric acid (1 vol. acid to 1 vol. water).
Ammonium oxalate, 5 per cent.
Ammonium sulphide, 1 vol. to 1 vol. of water.
Barium chloride, 5 per cent. Use distilled water or water free from sulphates.
Barium hydroxide, 1 per cent. Use clear solution.
Battery solution (Grenet). Dissolve 103 gm. of powdered potassium dichromate in 1000 cc. of water and slowly add 103 gm. of concentrated sulphuric acid with constant stirring. (A storage battery or reduced street current is preferable.)
Calcium hydroxide. *See* Limewater.
Chlorine water. Saturate water with the gas.
Cobaltous nitrate, 5 per cent.
Cochineal. Grind a little cochineal with water, dilute as desired, and filter.
Developer (photographic). Dissolve 11.5 gm. of hydroquinone, 38 gm. of sodium sulphite, 75 gm. of sodium carbonate, and 2 gm. of potassium bromide in 1000 cc. of water.

Fehling's solution. Dissolve 17.3 gm. of copper sulphate (cryst.) in 150 cc. of water. Dissolve 173 gm. of sodium citrate and 100 gm. of sodium carbonate (anhydrous) in 850 cc. of water. Pour the first solution into the second slowly with constant stirring. The final, clear solution will keep well.

Ferric chloride, 5 per cent.

Ferrous sulphate, 5 per cent. Must be freshly prepared. Keep a few pieces of iron in the solution.

Hydrochloric acid, dilute, 1 vol. to 5 vols. of water.

Lead salts. Use distilled water or filter.

Limewater. Slake lime, add considerable water, shake occasionally, and siphon off the clear liquid.

Litmus. As under Cochineal.

Mercuric chloride, 5 per cent. POISON!

Mercurous nitrate, 5 per cent. Add a little mercury.

Molisch's solution. Dissolve 10 gm. of alpha-naphthol in 100 cc. of ethyl alcohol (95 per cent).

Nitric acid, dilute, 1 vol. to 5 vols. of water.

Phenol-phthalein. Dissolve 1 gm. in 100 cc. of alcohol and dilute slightly with water.

Potassium permanganate, 5 per cent. (Add sufficient water to obtain "very dilute" solution.)

Potassium sulphocyanate, 5 per cent.

Silver nitrate, 5 per cent. Use distilled water (or water free from chlorides).

Silver sulphate, 0.5 per cent. See Silver nitrate.

Sodium cobaltinitrite. Dissolve 10 gm. of sodium nitrite in 20 cc. of water; dissolve 6 cc. of acetic acid and 1 gm. of cobaltous nitrate in 15 cc. of water. Mix these solutions and filter.

Stannous chloride. Reduce concentrated hydrochloric acid with tin, dilute with water, and keep tin in this solution.

Sulphuric acid, dilute, 1 vol. to 5 vols. of water. Pour the acid slowly into the water, stirring constantly.

INDEX

(*Numbers indicate pages*)